UNIVERSITY OF KERALA

Four Year Under Graduate Programme

(UoK FYUGP)

Syllabus

Major Discipline: CHEMISTRY

University of Kerala

Senate House Campus, Palayam, Thiruvananthapuram- 34, Kerala, India

May 2024

CONTENTS

1. BOARD OF STUDIES

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3. PREFACE

The scientific field of **chemistry** focuses on the properties, structure, organization, and transformations of matter. Chemistry's primary goal is to comprehend the fundamental ideas behind how atoms and molecules behave, from the smallest particles to complex chemical systems. Chemists study how different substances interact with one another and how energy changes during chemical processes are illustrated through observation, experimentation, and theoretical modelling. Organic, inorganic, physical, theoretical, polymer, analytical, and material chemistries are just a few of the many subfields that together make up the large field of chemistry. Each one offers a different approach for exploring the complex nature of matter and how it changes.

Undergraduate chemistry program exposes learners in the key concepts and procedures of the field, helping them to develop a solid theoretical foundation and practical skills that are necessary for their future employment in science. Through laboratory experiments, coursework, and research projects, students explore the principles of theory, gaining hands-on experience in chemical analysis, synthesis, and characterization techniques. Additionally, undergraduate chemistry program often highlights critical thinking, problem-solving, and interdisciplinary collaboration, preparing students for diverse career paths in academics, industry, healthcare and environmental science.

The **four-year undergraduate program (FYUGP) in chemistry**, emphasizes a holistic and multidisciplinary approach to education. This program integrates foundational coursework in chemistry with electives from related fields, encouraging a comprehensive understanding of chemical principles and their real-world applications. The FYUGP consists of Six different types of courses- (i) Core courses, (ii) Minor courses (DSCs), (iii) Discipline Specific Elective Courses (DSE), (iv) Multi-Disciplinary Courses (MDC), (v) Value Added Courses (VAC) and (vi) Skill Enhancement Courses (SEC). The students have the flexibility to change their major at the end of the first year and to select the minor courses from the broad list of courses provided by the university. The students who opt Honours with Research can carry out a research project in their core/elective areas of study along with capstone courses in the fourth year. The programme offers multiple bunches of elective courses which they can opt at their own interest. It provides opportunity for students to choose from multiple academic and career options.

The students are provided with diverse learning environments rather than mere memorization and rote learning of content. The curriculum is designed to promote critical thinking, problem-solving, and research skills through hands-on laboratory experiments, project-based learning, and opportunities for internships and industry collaborations. The provision for internships in industries and reputed institutes will enable students to be employable and aware of industry academic linkages. It is believed that this programme will provide students with a strong foundation in the discipline while exposing them to cutting-edge developments in the field. The multidisciplinary and holistic nature of the programme is believed to equip students with the skills and knowledge necessary for success in a rapidly changing world.

Also, the program incorporates elements of digital literacy, communication skills, and ethical practices to prepare students for leadership roles in different sectors. By offering a well-rounded education that combines theoretical knowledge with practical experience, the four-year undergraduate program in chemistry aims to nurture innovative thinkers, lifelong learners and responsible global citizens who can contribute to scientific advancements and societal development in India and beyond.

4. GRADUATE ATTRIBUTES

Graduate attributes bridge the gap between academia and the real world, fostering lifelong learning and meaningful contributions. They denote the skills, competencies and high-level qualities that a student should acquire during their university education. Apart from gathering content knowledge, these attributes go beyond the assimilation of information to its application in various contexts throughout a graduate's life. It aims in inculcating the art of critical thinking, problem solving, professionalism, leadership readiness, teamwork, communication skills and intellectual breadth of knowledge. The University of Kerala envisages to pave the path in guiding the student's journey to shape these attributes uniquely, making them integral to personal growth and success in various spheres of life. The University strives to ensure that these graduate attributes are not just checkboxes, but they play a pivotal role in shaping the students into capable, compassionate and responsible individuals with a high degree of social responsibility.

5. PROGRAMME OUTCOMES

No.	Programme Outcomes (POs)
PO-1	**Critical thinking** • Analyze information objectively and make a reasoned judgment. • Draw reasonable conclusions from a set of information, and discriminate between useful and less useful details to solve problems or make decisions. • Identify logical flaws in the arguments of others. • Evaluate data, facts, observable phenomena, and research findings to draw valid and relevant results that are domain-specific.
PO-2	**Complex problem-solving** • Solve different kinds of problems in familiar and no-familiar contexts and apply the learning to real-life situations. • Analyze a problem, generate and implement a solution and to assess the success of the plan. • Understand how the solution will affect both the people involved and the surrounding environment.
PO-3	**Creativity** • Produce or develop original work, theories and techniques. • Think in multiple ways for making connections between seemingly unrelated concepts or phenomena. • Add a unique perspective or improve existing ideas or solutions. • Generate, develop and express original ideas that are useful or have values.
PO-4	**Communication skills** • Convey or share ideas or feelings effectively. • Use words in delivering the intended message with utmost clarity.

	• engage the audience effectively. • Be a good listener who are able to understand, respond and empathize with the speaker. • Confidently share views and express himself/herself.
PO-5	**Leadership qualities** • Work effectively and lead respectfully with diverse teams. • Build a team working towards a common goal. • Motivate a group of people and make them achieve the best possible solution. • Help and support others in their difficult times to tide over the adverse situations with courage.
PO-6	**Learning ‘how to learn’ skills** • Acquire new knowledge and skills, including ‘learning how to learn skills, that are necessary for pursuing learning activities throughout life, through self-paced and self-directed learning. • Work independently, identify appropriate resources required for further learning. • Acquire organizational skills and time management to set self-defined goals and targets with timelines. • Inculcate a healthy attitude to be a lifelong learner.
PO-7	**Digital and technological skills** • Use ICT in a variety of learning and work situations, access, evaluate, and use a variety of relevant information sources. • Use appropriate software for analysis of data. • Understand the pitfalls in the digital world and keep safe from them.
PO-8	**Value inculcation** • Embrace and practice constitutional, humanistic, ethical, and moral values in life including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values. • Formulate a position/argument about an ethical issue from multiple perspectives. • Identify ethical issues related to work, and follow ethical practices, including avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data, or committing plagiarism, and adhering to intellectual property rights. • Adopt an objective, unbiased, and truthful actions in all aspects of work.

6. PROGRAMME SPECIFIC OUTCOMES

Upon completion of BSc Degree programme in Chemistry, students

PSO	Details	Key concept
PSO-1	Acquire expertise across chemistry domains: physical, organic, inorganic, and analytical. Proficiently predict reaction pathways, analyze outcomes, and interpret data using advanced analytical methods. Employ instruments for modeling chemical processes and evaluate theories and methods. Improve communication skills with chemistry software for creating molecular structures and visuals.	Mastery of Chemical reactions
PSO-2	Analyze chemical processes, apply findings to problem-solving, and utilize advanced analytical techniques. Embrace sustainability by using chemical software and tools responsibly, and cultivate an eco-friendly mindset by understanding pollution impacts on air, water, and soil.	Sustainable chemical analysis
PSO-3	Inculcate the spirit of originality, novelty, and necessity in scientific research and, thereby, develop a mindset to scientifically recognize, evaluate, and creatively solve research challenges and share knowledge in an interdisciplinary way to contribute to society's academic and industrial needs	Interdisciplinary skills
PSO-4	Proficiency in handling hazardous chemicals, recognizing common home chemicals' components, and applying them with caution. Visit chemical factories and industries with scientific curiosity to adopt safer life skills in a human-friendly and eco-friendly manner.	Safety and social responsibility
PSO-5	Foster a scientific mindset and critical thinking in Chemistry, promoting healthier attitudes towards individuals, communities, and cultures. Cultivate motivation for advanced studies and successful careers in academia, industry, research, and beyond.	Scientific perspective and student progression

7. COURSE CATEGORY CODES

Sl No	Name of Course	Course Category Code
1	Ability Enhancement Course	AEC
2	Multi-Disciplinary Course	MDC
3	Discipline Specific Core	DSC
4	Discipline Specific Elective	DSE
5	Value Addition Course	VAC
6	Skill Enhancement Course	SEC

8. FOUR YEAR UG PROGRAM IN CHEMISTRY

Course Structure

Semester	Course	Credit	No. of courses	Minimum credit to be earned in the semester
I	Ability Enhancement Course 1 (**AEC1** - English)	3	6	21
	Ability Enhancement Course 2 (**AEC2** – Other Language)	3		
	Multi-Disciplinary Course 1 (**MDC1**)	3		
	Discipline Specific Core Course 1 (**DSC1 – A1**)	4		
	Discipline Specific Core Course 2 (**DSC2 – B1**)	4		
	Discipline Specific Core Course 3 (**DSC3 – C1**)	4		
II	Ability Enhancement Course 3 (**AEC3** - English)	3	6	21
	Ability Enhancement Course 4 (**AEC4** – Other Language)	3		
	Multi-Disciplinary Course 2 (**MDC2**)	3		
	Discipline Specific Core Course 4 (**DSC4 – A2**)	4		
	Discipline Specific Core Course 5 (**DSC5 – B2**)	4		
	Discipline Specific Core Course 6 (**DSC6 – C2**)	4		
III	Multi-Disciplinary Course 3 (**MDC3** – Kerala Studies)	3	6	22
	Value Addition Course 1 (**VAC1**)	3		
	Discipline Specific Core Course 7 (**DSC7 – A3**)	4		
	Discipline Specific Core Course 8 (**DSC8 – B3**)	4		
	Discipline Specific Core Course 9 (**DSC9 – C3**)	4		
	Discipline Specific Elective Course 1 (**DSE1**)	4		
IV	Value Addition Course 2 (**VAC2**)	3	6	21
	Value Addition Course 3 (**VAC3**)	3		
	Skill Enhancement Course 1 (**SEC1**)	3		
	Discipline Specific Core Course 10 (**DSC10 – A4**)	4		

	Discipline Specific Core Course 11 (**DSC11 – A5**)	4		
	Discipline Specific Elective Course 2 (**DSE2**)	4		
INDUSTRY INTERNSHIP		2		2
V	Skill Enhancement Course 2 (**SEC2**)	3	6	23
	Discipline Specific Core Course 12 (**DSC12 – A6**)	4		
	Discipline Specific Core Course 13 (**DSC13 – A7**)	4		
	Discipline Specific Core Course 14 (**DSC14 – A8**)	4		
	Discipline Specific Elective Course 3 (**DSE3**)	4		
	Discipline Specific Elective Course 4 (**DSE4**)	4		
VI	Skill Enhancement Course 3 (**SEC3**)	3	6	23
	Discipline Specific Core Course 15 (**DSC15 – A9**)	4		
	Discipline Specific Core Course 16 (**DSC16 – A10**)	4		
	Discipline Specific Core Course 17 (**DSC17 – A11**)	4		
	Discipline Specific Elective Course 5 (**DSE5**)	4		
	Discipline Specific Elective Course 6 (**DSE6**)	4		
VII	Discipline Specific Core Course 18 (**DSC18 – A12**)#	4	6	24
	Discipline Specific Core Course 19 (**DSC19 – A13**)#	4		
	Discipline Specific Core Course 20 (**DSC20 – B4/C4**)*	4		
	Discipline Specific Core Course 21 (**DSC21 – B5/C5**)*	4		
	Discipline Specific Core Course 22 (**DSC22 – B6/C6**)*	4		
	Discipline Specific Elective Course 7 (**DSE7**)	4		
VIII	Discipline Specific Core Course 23 (**DSC23 – A14**)**	4	4	20
	Discipline Specific Core Course 24 (**DSC24 – A15**)**	4		
	CAPSTONE INTERNSHIP PROJECT / HONOURS WITH RESEARCH PROJECT	12		

- Advanced Level Course, * - 300-399 level Course, ** - Online Course

9. SPECIALIZATION STREAMS & COURSE CODES

Sl. No	Stream	Sem 3	Sem 4	Sem 5	Sem 6	Sem 7
1	Environmental Chemistry	UK3DSECHE200	UK4DSECHE200	UK5DSECHE300 UK5DSECHE301	UK6DSECHE300 UK6DSECHE301	UK7DSECHE400
2	Chemistry For Renewable & Clean Energy	UK3DSECHE201	UK4DSECHE201	UK5DSECHE302 UK5DSECHE303	UK6DSECHE302 UK6DSECHE303	
3	Analytical Chemistry	UK3DSECHE202	UK4DSECHE202	UK5DSECHE304 UK5DSECHE305	UK6DSECHE304 UK6DSECHE305	
4	Industrial Chemistry	UK3DSECHE203	UK4DSECHE203	UK5DSECHE306 UK5DSECHE307	UK6DSECHE306 UK6DSECHE307	
5	Polymer Chemistry	UK3DSECHE204	UK4DSECHE204	UK5DSECHE308 UK5DSECHE309	UK6DSECHE308 UK6DSECHE309	
6	Forensic Chemistry	UK3DSECHE205	UK4DSECHE205	UK5DSECHE310 UK5DSECHE311	UK6DSECHE310 UK6DSECHE311	
7	Chemistry of Nanomaterials	UK3DSECHE206	UK4DSECHE206	UK5DSECHE312 UK5DSECHE313	UK6DSECHE312 UK6DSECHE313	
8	Medicinal & Pharmaceutical Chemistry	UK3DSECHE207	UK4DSECHE207	UK5DSECHE314 UK5DSECHE315	UK6DSECHE314 UK6DSECHE315	

(Four courses are compulsory for getting specialization in that particular stream)

10. PRACTICALS

Specified number of practials in all practical modules are compulsory and remaining are open-ended, can be designed by the teacher in charge.

11. TEACHER CONTENT

Fifth module of all theory only courses are open-ended. It should be engaged by the teacher with activities related to the course such as learning through problem solving, seminars, open discussions, assignment discussions, quizzes, open book exams etc. Extra contents also may be added to the open-ended module with the prior approval of the BoS (pass) Chemistry.

12. STUDY TOUR AND FACTORY VISIT

A study tour to places of interest in India with a focus on secularism and oneness promotes intercultural understanding, tolerance, and the appreciation of diversity, fostering the values of secularism and unity in a multicultural society. Field visits provide students with practical, hands-on experiences that enhance their understanding of theoretical concepts taught in the classroom. By experiencing real-world applications of what they learn, students are better equipped to grasp and retain knowledge. This engagement can lead to improved academic performance and a deeper comprehension of the subject matter. Students are directed to visit at least one chemical factory during their fifth/sixth semester if study and submit scientifically prepared hand written study tour report along with photographs of candidate at the places of visit for ESE of practicals in sixth semester.

13. INDEX OF COURSES – FYUGP CHEMISTRY

70	5	UK5DSECHE313	CHEMISTRY OF NANOMATERIALS - IV	DSE	365
71	5	UK5DSECHE314	MEDICINAL & PHARMACEUTICAL CHEMISTRY - III	DSE	371
72	5	UK5DSECHE315	MEDICINAL & PHARMACEUTICAL CHEMISTRY - IV	DSE	376
73	5	UK5SECCHE300	ANALYTICAL SKILLS	SEC	380
74	5	UK5SECCHE301	PREPARATION & FORMULATION OF HERBAL PRODUCTS	SEC	384
75	6	UK6DSCCHE300	PHYSICAL CHEMISTRY - III	DSC	389
76	6	UK6DSCCHE301	ANALYTICAL PRINCIPLES - II	DSC	395
77	6	UK6DSCCHE302	ORGANIC CHEMISTRY - IV	DSC	401
78	6	UK6DSCCHE303	THEORETICAL CHEMISTRY - II	DSC	406
79	6	UK6DSCCHE304	PHYSICAL CHEMISTRY - IV	DSC	412
80	6	UK6DSCCHE305	ORGANIC CHEMISTRY - V	DSC	417
81	6	UK6DSECHE300	ENVIRONMENTAL CHEMISTRY - V	DSE	422
82	6	UK6DSECHE301	ENVIRONMENTAL CHEMISTRY - VI	DSE	426
83	6	UK6DSECHE302	CHEMISTRY FOR RENEWABLE & CLEAN ENERGY - V	DSE	431
84	6	UK6DSECHE303	CHEMISTRY FOR RENEWABLE & CLEAN ENERGY - VI	DSE	437
85	6	UK6DSECHE304	ANALYTICAL CHEMISTRY - V	DSE	443
86	6	UK6DSECHE305	ANALYTICAL CHEMISTRY - VI	DSE	448
87	6	UK6DSECHE306	INDUSTRIAL CHEMISTRY - V	DSE	454
88	6	UK6DSECHE307	INDUSTRIAL CHEMISTRY - VI	DSE	458
89	6	UK6DSECHE308	POLYMER CHEMISTRY - V	DSE	463
90	6	UK6DSECHE309	POLYMER CHEMISTRY - VI	DSE	468
91	6	UK6DSECHE310	FORENSIC CHEMISTRY - V	DSE	473
92	6	UK6DSECHE311	FORENSIC CHEMISTRY - VI	DSE	478
93	6	UK6DSECHE312	CHEMISTRY OF NANOMATERIALS - V	DSE	483

94	6	UK6DSECHE313	CHEMISTRY OF NANOMATERIALS - VI	DSE	489
95	6	UK6DSECHE314	MEDICINAL & PHARMACEUTICAL CHEMISTRY - V	DSE	495
96	6	UK6DSECHE315	MEDICINAL & PHARMACEUTICAL CHEMISTRY - VI	DSE	500
97	6	UK6SECCHE300	CHROMATOGRAPHY	SEC	505
98	6	UK6SECCHE301	COMPUTERS IN CHEMICAL SCIENCE	SEC	509
99	7	UK7DSCCHE400	ADVANCED INORGANIC CHEMISTRY I	DSC	514
100	7	UK7DSCCHE401	ADVANCED INORGANIC CHEMISTRY II	DSC	519
101	7	UK7DSCCHE402	ADVANCED ORGANIC CHEMISTRY	DSC	524
102	7	UK7DSCCHE403	ADVANCED PHYSICAL CHEMISTRY	DSC	529
103	7	UK7DSCCHE404	ADVANCED THEORETICAL CHEMISTRY I	DSC	534
104	7	UK7DSCCHE405	ADVANCED THEORETICAL CHEMISTRY II	DSC	539
105	7	UK7DSECHE400	RESEARCH METHODOLOGY & ETHICS	DSE	544
106	8	UK8CIPCHE400	CAPSTONE INTERNSHIP PROJECT	CIP	
107	8	UK8RPHCHE400	HONOURS WITH RESEARCH PROJECT	RPH	
108	8	UK8DSCCHE400	ONLINE*	DSC	
109	8	UK8DSCCHE401	ONLINE*	DSC	

SEMESTER I

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1DSCCHE100**				
Course Title	**INORGANIC CHEMISTRY I**				
Type of Course	**DSC**				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge				
Course Summary	This course provides an understanding of atomic structure, chemical bonding theories, environmental chemistry focusing on air, water, and soil pollution, and basics of analytical chemistry including volumetric analysis techniques. Through theoretical concepts, practical experiments, and case studies, students gain knowledge and skills essential for addressing complex issues in chemistry and environmental science.				

Detailed Syllabus:

Module	Unit	Content INORGANIC CHEMISTRY I	Hrs 75
I	**ATOMIC STRUCTURE & PERIODICITY**		**9**
	1	Introduction to structure of atom, Rutherford and Bohr model of atom	1
	2	Dual nature of electron-de Broglie equation-matter waves and electromagnetic waves. Experimental verification by Davis and Germer method, Heisenberg's uncertainty principle- expression and significance.	1
	3	Wave mechanical concept of the atom-Schrodinger equation and its significance (derivation not required.)	1
	4	Quantum numbers- Pauli's Exclusion principle- Aufbau Principle- Hund's rule- Electronic configuration of atoms, classification of elements into s, p, d and f blocks	2
	5	Electronegativity- Pauling's scale, Mulliken and Allred- Rochow scale (including numerical problems),	2
	6	Effective nuclear charge, Slaters rule and its applications, diagonal relationship and anomalous behaviour of first element with other elements	2
II	**CHEMICAL BONDING**		**15**

	7	Overview of Chemical Bonding Theories: - Definition of chemical bonding. - Importance of understanding chemical bonding in chemistry and related fields.	1
	8	Valence Shell Electron Pair Repulsion (VSEPR) Theory - Explanation of VSEPR theory. - Predicting molecular geometry for molecules with bond pairs only. - Predicting molecular geometry for molecules with both bond pairs and lone pairs. - Application of VSEPR theory in predicting molecular properties.	2
	9	Valence Bond Theory (VBT) - Conditions of overlapping in VBT. - Types of overlapping (sigma, pi, delta). - Hybridization in molecules: sp, sp2, sp3, sp3d, sp3d2. - Limitations of VBT and its application to simple molecules.	2
	10	Molecular Orbital (MO) Theory - Introduction to MO theory. - Linear Combination of Atomic Orbitals (LCAO) method. - Formation of molecular orbitals in homonuclear diatomic molecules (C2, B2, N2, O2) and ions (O2+, O2-). - Formation of molecular orbitals in heteronuclear diatomic molecules (HF, NO, CO). - Calculations of bond order and its applications.	3
	11	Ionic Bonding - Explanation of ionic bonding, Ionic lattice energy of ionic compounds. - Bond-Lande equation and Born-Haber cycle. - Solvation energy and solubility of ionic solids. - Covalent character of ionic bonds. - Fajan's rules and their applications. - Polarity of covalent bonds. - Dipole moment and percentage of ionic character. - Relationship between dipole moment and molecular structure.	3
	12	Metallic Bonding - Overview of metallic bonding. - Free electron theory and band theory. - Explanation of conductance and malleability in metals.	1
	13	Secondary Forces - Explanation of hydrogen bonding. - Inter and intramolecular hydrogen bonding. - Applications of hydrogen bonding in biology, chemistry, and materials science. - Intermolecular interactions: ion-dipole interactions, van der Waals forces (dispersion forces, dipole-dipole interactions, ion-induced dipole interactions, dipole-induced dipole interactions).	2

	14	Case studies and Problem-solving Session Group problem-solving exercises related to molecular geometry, hybridization, bond calculations, and properties of molecules based on their bonding.	1
III	**ENVIRONMENTAL CHEMISTRY- AIR, WATER AND SOIL POLLUTION**		**9**
	15	Air pollution- Air pollution caused by fireworks, harmful effects of fireworks, acid rain, greenhouse effect, smog-classic and photochemical smog Ozone layer depletion, ozone hole, protection of ozone umbrella. Management of air pollution.	2
	16	Water pollution: causes- heat, industrial waste, sewage water, detergents, agricultural pollutants Treatment of industrial waste water- Activated charcoal, synthetic resins, reverse osmosis and electro dialysis (Mention Only), Quality of drinking water- Indian Standard and WHO standard- Dissolved oxygen- BOD, COD.	3
	17	Soil pollution: pesticides, fertilizers, Industrial waste, Plastic. Control of Plastic threat- importance of Plastic identification codes and Plastic recycling, use of biodegradable plastics (PGA, PLA and PHBV (mention only)	2
	18	Control of pollution. Pollution Control Board – Duties and responsibilities Mention environmental movements (Plachimada, Silent valley, movement against Endosulfan, Narmada Bachavo Andolan and Chipko movement)	2
IV	**BASICS OF ANALYTICAL CHEMISTRY**		**12**
	19	Measurement of physical properties: International system of units and definitions, scientific notation, significant figures.	2
	20	Mole concept and molar mass, Concentration of solutions: Molarity, Normality, Molality, Mole fraction.	2
	21	Principles of volumetric analysis, primary standard, secondary standard, standard solution. Accuracy, precision, sensitivity, and selectivity	1
	22	Theory of Acid- Base titration: Acidimetry, Alkalimetry: Basic concepts, principle and illustration with suitable example. Theory of acid-base indicators	3
	23	Definition of Redox Reactions, Balancing of redox equations, Theory of Redox titration: Titration of Fe^{2+} with $KMnO_4$ and $K_2Cr_2O_7$ and theory of redox indicators.	2
	24	Theory of complexometric titration: metal ion-EDTA titration. Theory of metallochromic indicators Precipitation titration: NaCl- $AgNO_3$ titration and use of potassium chromate as adsorption indicator.	2
V	**VOLUMETRIC ANALYSIS**		**30**
	25	**Section A: Volumetric Analysis (8 Experiments from Section A are compulsory)** 1. Preparation of standard solutions. 2. Neutralization Titrations a. Strong acid – Strong base b. Strong acid – weak base c. Weak acid – strong base.	15

		3. Redox Titrations - Permanganometry a. Estimation of oxalic acid. b. Estimation of $Fe^{2+}/FeSO_4.7H_2O$/Mohr's salt.	
	26	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** 1. Dichrometry 2. Iodometry & Iodimetry 3. Complexometry 4. Colorimetry	15

References:

1. B.R. Puri L.R. Sharma, K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.
3. R. Gopalan, V.Ramalingam, *Concise Coordination Chemistry*, 1st Edn.,Vikas Publishing House, New Delhi, 2001.
4. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, 5th Edn., Vol. I, S Chand, 2012.
5. G. S. Manku, *Theoretical Principles of Inorganic Chemistry*. McGraw-Hill Education; New edition (1 August 1982)
6. M.C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.
7. J. E. Huheey, E.A. Keitler, R. L. Keitler, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi,2013.
8. B.K. Sharma, *Industrial chemistry*, 11th Edn., Goel publishing House, Meerut, 2000.
9. M.N. Greenwood, A. Earnshaw, *Chemistry of elements*, 2nd Edn., Butterworth,1997.
10. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.
11. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.

Further Reading

1. James E. House, *Inorganic Chemistry*, academic press, 2008.
2. W.U. Malik, G.D.Tuli, R.D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand and Co., New Delhi, 2010.
3. F.A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley India Pvt. Ltd., New Delhi,2009.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Learn about quantum numbers, electron configurations, and periodic trends, enabling to classify elements and predict their properties accurately	R, U	PSO -1
CO-2	Learn to predict molecular geometry, hybridization, and bond properties, enabling to analyze and interpret the behavior of molecules in various chemical contexts.	U, Ap	PSO -1,2,3
CO-3	Apply the theories to real-world scenarios, developing critical thinking and analytical skills.	Ap	PSO -1,2,3
CO-4	Gain an understanding of pollution and management strategies.	U	PSO -2,3,4
CO-5	Learn about environmental movements aimed at addressing pollution issues, fostering awareness and promoting sustainable practices for a healthier environment.	Ap, An	PSO -2,3.4
CO-6	Proficiency in the application of the mole concept and concentration terms, enabling to perform accurate and precise chemical analyses and interpret the results effectively.	Ap	PSO -1,2,3
CO-7	Develop practical skills in chemical analysis and data interpretation, preparing for advanced laboratory work and real-world applications in analytical chemistry.	Ap, E	PSO - 1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INORGANIC CHEMISTRY 1

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO – 1 PSO -1	R, U	F, C	L	-
2	CO-2	PO -1, 2, 3, 6 PSO -1,2,3	U, Ap	F, C	L	-

3	CO-3	PO – 1, 2, 6 PSO -1,2,3	Ap	F, C	L	-
4	CO-4	PO – 2,3,8 PSO -2,3,4	U	F, C	L	-
5	CO-5	PO – 1,2,3,5,8 PSO -2,3.4	Ap, An	F, C, M	L	-
6	CO-6	PO – 1,2,6 PSO -1,2,3	Ap	F, C, M	L	-
7	CO-7	PO – 1,2,3,6 PSO -1,2,3,4,5	Ap, E	C, P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	-	-	1	-	-	-	-	-	-	-
CO 2	2	2	3	-	-	1	1	1	-	-	2	-	-
CO 3	2	3	3	-	-	1	1	-	-	-	2	-	-
CO 4	-	2	3	2	-	-	2	2	-	-	-	-	3
CO 5	-	2	3	2	-	1	2	1	-	2	-	-	2
CO 6	3	2	3	-	-	1	2	-	-	-	3	-	-
CO 7	3	2	3	2	3	1	2	2	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓			✓
CO 7	✓			✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1DSCCHE101**				
Course Title	**FUNDAMENTALS OF CHEMISTRY I**				
Type of Course	**DSC**				
Semester	I				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge				
Course Summary	The course covers fundamental principles in the periodic classification of elements, chemical bonding, thermodynamics and thermochemistry, analytical principles, and lab safety, providing students with a comprehensive understanding of key concepts in chemistry. Through both theoretical learning and hands-on practicals in volumetric analysis, students develop essential skills for analytical chemistry and gain practical experience in experimental techniques.				

Detailed Syllabus:

Module	**Unit**	**Contents** **FUNDAMENTALS OF CHEMISTRY I**	**Hrs** **75**
I	**PERIODIC CLASSIFICATION OF ELEMENTS**		**9**
	1	Quantum numbers and their significance, Concept of orbitals.	2
	2	Orbital wise electron configuration, energy sequence rule – Pauli's principle, Hund's rule, stability of filled and half-filled orbitals	2
	3	Electronic configuration and classification of elements in to s,p,d and f blocks.	1
	4	Periodic properties, Ionisation energy, Electronegativity and Electron affinity. Diagonal relationship.	2
	5	Important characteristics of representative elements: valency, oxidation states, ionic and covalent bond formation Important characteristics of transition elements: variable valency and oxidation states, formation of Complex compounds.	2
II	**CHEMICAL BONDING**		**9**
	6	Energetic of bond formation – Types of Chemical bonds – Energetics of ionic bond formation – Lattice energy – Born Haber Cycle - Fajan's rules.	2

	7	Polarity of covalent bond its relation with electronegativity Electro negativity scales – Paulings and Mullikan's approaches, factors influencing polarity Dipole moment – its relation to geometry.	2
	8	Hydrogen bond – inter and intra molecular – its consequences on boiling point, volatility and solubility.	1
	9	Concept of Hybridisation– sp, sp^2, sp^3, dsp ^{2}, dsp^3, sp $^3d^2$, and sp^3d^3 with examples Explanation of bond angle in water and ammonia- VSEPR theory, geometry of molecules with bond pairs of electrons, bond pairs and lone pairs of electrons, limitations of VSEPR Theory.	2
	10	A brief review of molecular orbital approach, LCAO method – bond order, bond distance and stability of O_2, O_2^{2+}, O_2^{2-} , NO, NO^+, CO and HF.	2
III	**THERMODYNAMICS AND THERMOCHEMISTRY**		**18**
	11	First law of thermodynamics, mathematical form, intrinsic energy, enthalpy, reversible, process and maximum work, work of expansion of an ideal gas in reversible isothermal process.	3
	12	Heat capacity of gases at constant volume and constant pressure, derivation of $C_P – C_V = R$.	2
	13	Second law of thermodynamics, entropy and free energies Significance of Δ G, Δ H and available work Criteria of equilibrium, and spontaneity on the basis of entropy and free energy, Gibbs - Helmholtz equation.	4
	14	Enthalpies of formation, combustion, neutralization, solution and hydration	2
	15	Relation between heat of reaction at constant volume and constant pressure Variation of heat of reaction with temperature- Kirchoff's equation	3
	16	Hess's law and application – bond dissociation energies and bond energies of different types of bonds, their calculation and enthalpies of reaction	4
IV	**ANALYTICAL PRINCIPLES & LAB SAFETY**		**9**
	17	Analytical methods in Chemistry – Principles of volumetric analysis, primary standard, standard solution, Calculation of normality, molality and molarity of solutions	2
	18	Theory of acid - base titrations: Strong acid - Strong Base, Strong acid - weak base, Weak acid Strong base and weak acid-strong base (Explanation with titration curves) Redox titrations: Permanganometry-Fe^{2+} and $KMnO_4$ and dichrometry - Fe^{2+} and $K_2Cr_2O_7$, Theory of acid – base and redox indicators.	2
	19	Inorganic qualitative analysis, common ion effect- solubility product-precipitation and inter group separation of cations. Salting out process	2
	20	Chromatography- principle and applications of paper and thin layer chromatography,	2
	21	Lab safety - Risk, Hazard, Chemical Hazard**.**	1
V	**VOLUMETRIC ANALYSIS**		**30**

	22	**Section A: Volumetric Analysis (8 Experiments from Section A are compulsory)** 4. Preparation of standard solutions. 5. Neutralization Titrations d. Strong acid – Strong base e. Strong acid – weak base f. Weak acid – strong base. 6. Redox Titrations - Permanganometry c. Estimation of oxalic acid. d. Estimation of Fe^{2+}/$FeSO_4.7H_2O$/Mohr's salt.	15
	23	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** 1. Dichrometry 2. Iodometry & Iodimetry 3. Complexometry 4. Colorimetry	15

References

1. B.R Puri, L R Sharma K C Kalia, *Principles of Inorganic Chemistry*, Sobhanlal Nagin Chand & Co. New Delhi
2. Manas chanda, *Atomic structure and Chemical bonding in molecular spectroscopy*, Tata Mc Graw Hill.
3. S Glasstone, *Thermodynamics for Chemists*, Affiliated Eat West Publishers
4. J D Lee, *Concise Inorganic Chemistry*, ELBS.
5. R P Rastogi and R R Misra, *An Introduction to Thermodynamics*.
6. D.A Skoog, D M West, F J, Holler, S R Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brookes/Cole, Thomson Learning, Inc, USA, 2004.
7. Day and Underwood, *Quantitative analysis: Laboratory manual*.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the rules for filling electrons in atomic orbitals	U	PSO - 1
CO-2	Discuss theories of chemical bonding and their limitations	U	PSO - 1
CO3	Predict geometry of molecules from the type of hybridisation.	Ap	PSO – 1,2,3

CO 4	Recognise fundamentals of thermodynamics and the predict spontaneity of reactions.	Ap	PSO – 1,2,3
CO 5	Critically select suitable indicators for acid base and redox titrations	E	PSO – 1,2,3
CO 6	Apply the basic principles in qualitative analysis and identify cation and anion	Ap	PSO – 1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FUNDAMENTALS OF CHEMISTRY I

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO- 1,6 PSO - 1	U	F, C	L	-
2	CO-2	PO – 1,6 PSO - 1	U	F, C	L	-
3	CO3	PO-1,2,6 PSO – 1,2,3	Ap	F, C	L	-
4	CO 4	PO-1,6 PSO – 1,2,3	Ap	F, C	L	-
5	CO 5	PO-1,6 PSO – 1,2,3	E	F, C	L	-
6	CO 6	PO-1,2,6 PSO – 1,2,3,4	Ap	F, C, P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	-	-	1	-	-	-	-	2	-	-
CO 2	2	-	-	-	-	1	-	-	-	-	2	-	-
CO 3	2	1	3	-	-	1	1	-	-	-	2	-	-

CO 4	2	3	2	-	-	1	-	-	-	-	2	-	-
CO 5	2	3	3	-	-	1	-	-	-	-	2	-	-
CO 6	1	2	3	2	-	1	2	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓			✓
CO 5	✓	✓		✓
CO 6	✓			✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1DSCCHE102**				
Course Title	**CHEMICAL FRONTIERS – BONDING TO ENVIRONMENTAL PERSPECTIVES**				
Type of Course	**DSC**				
Semester	1				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge				
Course Summary	The course covers the periodic classification of elements, chemical bonding, organometallic chemistry, environmental pollution, and analytical principles, including volumetric analysis. Students learn about quantum numbers, orbital concepts, electron configuration, bond energetics, molecular geometry, and various analytical techniques for qualitative and quantitative analysis. They also gain an understanding of the biological, environmental, and industrial applications of chemistry.				

Detailed Syllabus:

Module	Unit	Content **CHEMICAL FRONTIERS – BONDING TO ENVIRONMENTAL PERSPECTIVES**	Hrs 75
1	**PERIODIC CLASSIFICATION OF ELEMENTS**		**9**
	1	Quantum numbers and their significance, Concept of orbitals.	2
	2	Orbital wise electron configuration, energy sequence rule – Pauli's principle, Hund's rule, stability of filled and half-filled orbitals.	2
	3	Electronic configuration and classification of elements in to s,p,d and f blocks	1
	4	Periodic properties, Ionisation energy, Electronegativity and Electron affinity. Diagonal relationship.	2
	5	Important characteristics of representative elements: valency, oxidation states, ionic and covalent bond formation Important characteristics of transition elements: variable valency and oxidation states, formation of Complex compounds.	2
II	**CHEMICAL BONDING**		**9**

	6	Energetic of bond formation – Types of Chemical bonds – Energetics of ionic bond formation – Lattice energy – Born Haber Cycle - Fajan's rules.	2
	7	Polarity of covalent bond its relation with electronegativity Electro negativity scales – Paulings and Mullikan's approaches, factors influencing polarity Dipole moment – its relation to geometry.	2
	8	Hydrogen bond – inter and intra molecular – its consequences on boiling point, volatility and solubility.	1
	9	Concept of Hybridisation– sp, sp^2, sp^3, dsp^2, dsp^3, sp $^3d^2$, and sp^3d^3 with examples Explanation of bond angle in water and ammonia - VSEPR theory, geometry of molecules with bond pairs of electrons, bond pairs and lone pairs of electrons, limitations of VSEPR Theory.	2
	10	A brief review of molecular orbital approach, LCAO method – bond order, bond distance and stability of O_2, O_2^{2+}, O_2^{2-} , NO, NO^+,CO and HF.	2
III	**ORGANOMETALLICS**		**9**
	11	Definition and classification, Organo metallic compounds of Mg, Sn, Li, Hg, Fe and their synthesis, applications	3
	12	Biological and environmental aspects of organic compounds – organometallic compounds in medicines – organomercury, organoboron, organosilicon and organo arsenic compounds	2
	13	Outline of preparation and uses Antitumour drugs, silylated derivatives of bioactive organic compounds in agriculture and horticulture	3
	14	Environmental aspects of Organometallic compounds	1
IV	**ENVIRONMENTAL POLLUTION AND ANALYTICAL PRINCIPLES**		**18**
	15	Air pollution: Composition of air, major causes of air pollution	2
	16	Pollutants in air-carbon monoxide, carbon dioxide, oxides of Nitrogen and sulphur, chlorofluro carbons- effect of using refrigerators and air conditioners, Particulate matter- Acid rain, Greenhouse effect, ozone layer and its depletion	2
	17	Water pollution: causes- heat, industrial waste, sewage water, detergents, agricultural pollutants	2
	18	Treatment of industrial waste water- Activated charcoal, Reverse osmosis Quality of drinking water- Indian Standard and WHO standard- Dissolved oxygen- BOD, COD	2
	19	Soil pollution: pesticides, fertilizers, Industrial waste, Plastic.	1
	20	Principles of volumetric analysis- primary standard – standard solutions - normality and molarity	2
	21	Theory of acid - base titrations, permanganometric and dichrometric titrations, iodometric and complexometric titrations	2
	22	Theory of acid – base and redox indicators	2
	23	Beer- Lambert law- Principles of colorimetry – Estimation of Iron and phosphate	2
	24	Lab safety - Risk, Hazard, Chemical Hazard.	1
V	**VOLUMETRIC ANALYSIS**		**30**

	25	**Section A: Volumetric Analysis (8 Experiments from Section A are compulsory)** 7. Preparation of standard solutions. 8. Neutralization Titrations g. Strong acid – Strong base h. Strong acid – weak base i. Weak acid – strong base. 9. Redox Titrations - Permanganometry e. Estimation of oxalic acid. f. Estimation of Fe^{2+}/$FeSO_4.7H_2O$/Mohr's salt.	15
	26	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** 1. Dichrometry 2. Iodometry & Iodimetry 3. Complexometry 4. Colorimetry	15

References

1. B.R Puri, L R Sharma K C Kalia, Principles of Inorganic Chemistry, Sobhanlal Nagin Chand & Co. New Delhi
2. Manas chanda, Atomic structure and Chemical bonding in molecular Spectroscopy, Tata Mc Graw Hill.
3. Malik, Tuli, Madan, Selected Topics in Inorganic chemistry, S Chand.
4. J D Lee, Concise Inorganic Chemistry, ELBS
5. D.A Skoog, D M West, F J, Holler, S R Crouch, Fundamentals of Analytical Chemistry,8th Edn., Brookes/Cole, Thomson Learning, Inc, USA, 2004.
6. A. I. Vogel, Quantitative Analysis.
7. Day and Underwood, Quantitative analysis: Laboratory manual.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the rules for filling electrons in atomic orbitals	U	PSO-1
CO-2	Discuss theories of chemical bonding and their limitations	U	PSO-1,2
CO3	Predict geometry of molecules from the type of hybridisation.	Ap	PSO-1,2,3
CO 4	Discuss the applications of organometallics.	U	PSO-1,2,3

CO 5	Critically select suitable indicators for acid base and redox titrations	E	PSO-1,2,3
CO 6	Apply the basic principles in quantitative analysis	Ap	PSO-1,2,3,4
CO 7	Discuss the factors affecting environmental pollution	U	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMICAL FRONTIERS – BONDING TO ENVIRONMENTAL PERSPECTIVES

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1	U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2	U	F, C	L	-
3	CO3	PO-1,3,6 PSO-1,2,3	Ap	F, C, P	L	-
4	CO 4	PO-1,6 PSO-1,2,3	U	F, C	L	-
5	CO 5	PO-1,2,3,6 PSO-1,2,3	E	F, C, P	-	P
6	CO 6	PO-1,2,6 PSO-1,2,3,4	Ap	F, C, P	-	P
7	CO 7	PO-1,6 PSO-1,2,3,4,5	U	F, C, M	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	-	-	1	-	-	-	-	2	-	-
CO 2	2	1	-	-	-	1	-	-	-	-	2	-	-
CO 3	2	2	3	-	-	1	-	1	-	-	2	-	-

CO 4	2	1	3	-	-	1	-	-	-	-	2	-	-
CO 5	2	2	3	-	-	1	1	1	-	-	2	-	-
CO 6	2	2	3	3	-	1	1	-	-	-	2	-	-
CO 7	2	2	2	3	2	1	-	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓	✓	✓
CO 5	✓			✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1DSCCHE103**				
Course Title	**FOUNDATIONS OF INORGANIC & POLYMER CHEMISTRY**				
Type of Course	**DSC**				
Semester	1				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge				
Course Summary	The course covers fundamental topics in chemistry, including atomic structure, periodicity, environmental pollution, polymers, and analytical principles. Students will gain a comprehensive understanding of these concepts, along with practical skills in volumetric analysis, preparing them for careers in fields such as chemistry, environmental science, and materials science with an emphasis on theoretical knowledge and hands-on laboratory experience.				

Detailed Syllabus:

Module	Unit	Content FOUNDATIONS OF INORGANIC & POLYMER CHEMISTRY	Hrs 75
I	**ATOMIC STRUCTURE & PERIODICITY**		**18**
	1	Atomic structure – Introduction - Atomic spectrum of Hydrogen – different series, Rydberg equation, Bohr theory –postulates – statement of Bohr energy equation, limitations of Bohr model	4
	2	Dual nature of matter and radiation, Photoelectric effect, de Broglie equation, Heisenberg’s uncertainty principle	3
	3	Concept of orbital, Quantum numbers, shapes of orbitals (s, p, d)	2
	4	Electronic configuration of atoms - Aufbau principle, Hund’s rule of maximum multiplicity, Pauli’s exclusion principle.	3
	5	Modern periodic law – Long form of periodic table	1
	6	Periodicity in properties: Atomic radii, ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy) and electronegativity (Pauling scale).	3
	7	Atomic mass - Molecular mass – Mole concept – Molar volume - Oxidation and reduction – Oxidation number and valency - Equivalent mass.	2
II	**ENVIRONMENT AND POLLUTION**		**9**

	8	Air and soil pollution - Introduction, different types of air and soil pollution, air pollutants SO_2, SO_3, NO, NO_2 and smog.	2
	9	Acid rains, CO_2, CO, Greenhouse effect, O_3, importance of ozone layer, causes and effects of ozone layer depletion.	2
	10	Photochemical oxidants, PAN, hydrocarbons, particulates, dust, smog, asbestos, lead, mercury, cadmium. Control of air pollution	2
	11	Water pollution-Factors affecting the purity of water, sewage water, Industrial waste, agricultural pollution such as pesticides, fertilizers, detergents; treatment of industrial waste water using activated charcoal, synthetic resins, reverse osmosis and electro dialysis (elementary idea only).	3
III	**NATURAL AND SYNTHETIC POLYMERS**		**9**
	12	Introduction. Classification of polymers: Natural, synthetic; linear, cross-linked and network polymers, plastics, elastomers, fibres; homopolymers and copolymers.	2
	13	Mode of formation - Addition, Condensation Polymerization (definition and examples only)	1
	14	Typical examples: Polyethylene, polypropylene, PVC, phenol-formaldehyde and melamine formaldehyde resins, polyamides (nylons) and polyesters.	3
	15	Natural rubber: structure, latex processing methods, vulcanization and uses. Synthetic rubbers: SBR, nitrile rubber and neoprene.	2
	16	Biodegradability of polymers, environmental hazards. Recycling of plastics.	1
IV	**ANALYTICAL PRINCIPLES**		**9**
	18	Reporting of Analytical Data: Units, significant digits, rounding, Precision and accuracy – Types of errors – Ways of expressing precision – Methods to reduce systematic errors.	2
	19	Methods of expressing concentration: Weight percentage, molality, molarity, normality, mole fraction, ppm and millimoles.	2
	20	Methods of Analysis: Volumetric method of analysis - General principles. Primary and secondary standards, criteria for primary standards, preparation of standard solutions, standardization of solutions, end point.	2
	21	Acid base, redox and complexometric titrations and corresponding indicators.	2
	22	Separation Techniques: General principles of distillation and solvent extraction.	1
V	**VOLUMETRIC ANALYSIS**		**30**
	23	**Section A: Volumetric Analysis (8 Experiments from Section A are compulsory)** 10. Preparation of standard solutions. 11. Neutralization Titrations j. Strong acid – Strong base k. Strong acid – weak base l. Weak acid – strong base. 12. Redox Titrations - Permanganometry:	15

		g. Estimation of oxalic acid. h. Estimation of Fe^{2+}/$FeSO_4.7H_2O$/Mohr's salt.	
	24	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** 1. Dichrometry 2. Iodometry & Iodimetry 3. Complexometry 4. Colorimetry	15

References:

1. *Elements of Physical Chemistry*, B. R. Puri, L. R. Sharma, M.S. Pathania, Vishal Pub. Co.
2. *Inorganic Chemistry*, P. L. Soni.
3. *Atomic Structure and Molecular Spectroscopy*, Manas Chanda,
4. *University General Chemistry*, C. N. R. Rao, Macmillan.
5. *Text Book of Environmental Studies for undergraduate Courses*, Bharucha Erach, University Press.
6. *Polymer Science* V.R. Gowarikar, Wiley Ester Ltd.
7. *Vogel's Text Book of Quantitative Chemical Analysis,* J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas, Pearson Education.
8. *Analytical Chemistry*, R. Gopalan, S. Chand and Co., New Delhi.
9. *Quantitative Analysis*, R. A. Day Junior, A.L. Underwood, 5th edn. Prentice Hall of India Pvt. Ltd. New Delhi.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explore fundamental principles of chemistry to enable a solid foundation for further studies and applications in various related fields.	R	PSO-1,2
CO-2	Equip with the fundamental concepts of periodicity, and apply the knowledge to analyze and predict chemical behaviour and properties.	R, Ap, An	PSO-1,2,3
CO-3	Understanding of environmental pollution issues and solutions, enabling to contribute to environmental protection and related problem solving	U, Ap	PSO-1,2,4
CO-4	Overview of polymers to equip with knowledge to address environmental concerns and promote sustainable practices in polymer production, use and recycling.	U, Ap	PSO-1,2,3,4
CO-5	Equip with theoretical knowledge necessary for accurate	R, U	PSO-1,2,3,4,5

	data analysis, concentration determination, and separation of substances, preparing for various careers in analytical chemistry.		
CO-6	Develop practical skills to do volumetric experiments in related areas of research and industry	An, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FOUNDATIONS OF INORGANIC & POLYMER CHEMISTRY

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO- 1,6 PSO-1,2	R	F, C	L	L
2	CO-2	PO- 1,6 PSO-1,2,3	R, Ap, An	F, C	L	L
3	CO-3	PO- 1,6 PSO-1,2,4	U, Ap	F, C	L	L
4	CO-4	PO- 1,6 PSO-1,2,3,4	U, Ap	F, C	L	L
5	CO-5	PO- 1,2,6 PSO-1,2,3	R, U	F, C, P	L	L
6	CO-6	PO- 1,2,6 PSO-1,2,3,4,5	An, E	F, C, P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	-	-	-	1	-	-	-	-	2	-	-
CO 2	2	2	3	-	-	1	-	-	-	-	2	-	-
CO 3	1	2	-	3	-	1	-	-	-	-	2	-	-
CO 4	2	2	3	3	-	1	-	-	-	-	2	-	-

CO 5	1	2	3	2	3	2	1	-	-	-	2	-	-
CO 6	1	2	3	3	3	2	2	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1DSCCHE104**				
Course Title	**GENERAL INORGANIC CHEMISTRY**				
Type of Course	**DSC**				
Semester	1				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge				
Course Summary	The course covers atomic structure, chemical bonding, co-ordination chemistry and secondary bond forces, analytical principles including volumetric analysis and Nuclear Chemistry. Students learn about quantum numbers, orbital concepts, electron configuration, bond energetics, molecular geometry, and fundamentals of analytical chemistry. They also gain a detailed understanding of the radioactivity and nuclear chemistry				

Detailed Syllabus:

Module	**Unit**	**Content** **GENERAL INORGANIC CHEMISTRY**	**Hrs** **75**
1	**Atomic Structure, Chemical bonding and Secondary bond forces**		**21**
	1	Atomic spectrum of hydrogen - different series, Rydberg equation. Bohr theory – postulates – statement of Bohr energy equation – derivation of spectral frequency from Bohr equation	3
	2	Schrodinger wave equation (mention only, no derivation), concept of orbitals. Quantum numbers and their significances	2
	3	Orbital wise electron configuration, energy sequence rule – Pauli's principle, Hund's rule, Stability of filled and half-filled orbitals.	3
	4	Electronic configuration of lanthanides and actinides, Lanthanide contraction	1
	5	Energetics of ionic bond formation – Born-Haber cycle. Fajan's rule.	3
	6	Hybridisation and shape of molecules with examples – sp ($BeCl_2$), sp2(BF_3) , sp3 (CH_4), sp3d(PCl_5), sp3d2 (SF_6) and sp3d3 (IF_7)	3
	7	VSEPR theory, regular and irregular geometry, H_2O, NH_3, XeF_2, XeF_4. Hydrogen bond – inter and intra molecular – its consequences on boiling point and volatility. Importance of hydrogen bonding in biomolecules – Proteins and nucleic acids.	3
	8	Ionic character of covalent bond – Polar and non-polar covalent compounds.	1
	9	Secondary bond forces in molecules – Ion-dipole, dipole-dipole, ion-induced dipole, dipole-induced dipole and induced dipole-induced dipole	2

		interactions.	
II	**Co-ordination chemistry**		**6**
	10	Types of ligands, Werner's coordination theory, Valence bond theory of bonding in octahedral and tetrahedral complexes, Drawbacks of valence bond theory.	3
	12	Crystal field theory of octahedral and tetrahedral complexes, examples – high and low spin complexes, magnetic properties, Application in qualitative and quantitative analysis	3
III	**Analytical Principles**		**9**
	12	Principles of volumetric analysis – primary standard – standard solutions normality and molarity	3
	13	Theory of acid-base titrations, permagnometric and dichrometric titrations, iodometry and complexometric titrations. Theory of acid-base indicator – redox indicators	3
	14	Principles of colorimetry – estimation of biomolecules - glucose and chlorophyll.	3
IV	**Radioactivity and Nuclear Chemistry**		**9**
	15	Radioactive decay series, Radioactive equilibrium, Average life, Half-life. Detection of radio activity-Geiger Muller Counter, Wilson cloud chamber. Units of radioactivity-Curie and Rutherford, Units of radiations.	3
	16	Nuclear Chemistry-stability of nucleus, n/p ratio. Artificial transmutation and radioactivity, mass defect, binding energy.	3
	17	Applications of radio activity- in medicine and agriculture. Biological effects of radiation, pathological and genetic damage.	3
V	**VOLUMETRIC ANALYSIS**		**30**
	18	**Section A: Volumetric Analysis (8 Experiments from Section A are compulsory)** 13. Preparation of standard solutions. 14. Neutralization Titrations m. Strong acid – Strong base n. Strong acid – weak base o. Weak acid – strong base. 15. Redox Titrations - Permanganometry i. Estimation of oxalic acid. j. Estimation of Fe^{2+}/$FeSO_4.7H_2O$/Mohr's salt.	15
	19	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** 1. Dichrometry 2. Iodometry & Iodimetry 3. Complexometry 4. Colorimetry	15

References

1. *Bosolo and Johns*, Co-ordination Chemistry.
2. *Rochoco*, Chemistry of Organometallics.
3. *J.D. Lee*, Concise Inorganic Chemistry.

4. Puri, Sharma and Kalia "*Inorganic Chemistry"*
5. A.D. Madan, *Modern Inorganic Chemistry*
6. A.I.Vogel, *A text book of Quantitative analysis"*
7. Day & Underwood, *Quantitative analysis: laboratory manual":*

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the rules for filling electrons in atomic orbitals	U	PSO-1
CO-2	Discuss theories of chemical bonding and their limitations	U	PSO-1
CO3	Predict geometry of molecules from the type of hybridisation.	Ap	PSO-1,2,3
CO 4	Discuss the important theories of coordination compounds	U	PSO-1
CO 5	Critically select suitable indicators for acid base and redox titrations	E	PSO-1,2,3
CO 6	Apply the basic principles in quantitative analysis	Ap	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Name of the Course: GENERAL INORGANIC CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1	U	F, C	L	-
2	CO-2	PO-1,6 PSO-1	U	F, C	L	-
3	CO3	PO-1,6 PSO-1,2,3	Ap	F, C, P	L	-
4	CO 4	PO-1,6 PSO-1	U	F, C	L	-
5	CO 5	PO-1,6	E	F, C, P	L	-

		PSO-1,2,3				
6	CO 6	PO-1,2,6 PSO-1,2,3,4,5	Ap	F, C, P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	-	-	-	-	2	-	-	-	-	2	-	-
CO 2	3	-	-	-	-	2	-	-	-	-	2	-	-
CO 3	3	2	2	-	-	2	-	-	-	-	2	-	-
CO 4	3	-	-	-	-	2	-	-	-	-	2	-	-
CO 5	2	2	2	-	-	2	-	-	-	-	2	-	-
CO 6	2	2	2	2	3	2	2	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5	✓			✓
CO 6	✓			✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1DSCCHE105**				
Course Title	**GENERAL CHEMISTRY I**				
Type of Course	**DSC**				
Semester	1				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	This course covers the fundamentals of scientific methodology, the evolution of chemistry, the contributions of notable scientists, chemistry's role in everyday life, lab safety, analytical principles, and practical experiments focusing on volumetric analysis and laboratory safety. Through theoretical understanding and hands-on experiments, students will gain essential knowledge and skills for a deeper comprehension of chemistry and its applications in various fields.				

Detailed Syllabus:

Module	Unit	Content GENERAL CHEMISTRY I	Hrs 75
I	**METHODOLOGY OF CHEMISTRY**		**9**
	1	Definition of Science. Scientific methods - observation-posing a question - formulation of hypothesis- experiment – theory - law. Falsification of hypothesis - inductive and deductive reasoning- revision of scientific theories and laws.	3
	2	Evolution of Chemistry-ancient speculation on the nature of matter. Early form of chemistry - alchemy, origin of modern chemistry. Structure of chemical science: Scope, theory and experiment - branches of chemistry.	3
	3	Role of chemistry as a central science connecting physics, biology and other branches of science. Interdisciplinary areas involving chemistry: Nanotechnology and biotechnology.	3
II	**POPULAR SCIENTISTS IN CHEMICAL SCIENCE**		**9**
	4	Some popular scientists and their contributions to the evolution of chemistry - Antoine Lavoisier, Dmitri Mendeleev, Marie Curie, Robert Boyle, John Dalton, Linus Pauling, Joseph Priestley, Friedrich Wöhler, J.J. Thomson, Amedeo Avogadro	6

	5	Women scientists in chemical science - Rosalind Franklin, Alice Ball, Dorothy Hodgkin, Gertrude Elion	3
III	**CHEMISTRY IN EVERYDAY LIFE**		**9**
	6	Household materials – Major chemical ingredients (No structural formula and preparation needed), Match Box-Soap- detergent— cooking gas –tooth paste – shampoo hair - dye- nail polish- whitener-moth balls, house hold bleach	5
	7	Method of action and possible hazards/toxicity of explosive chemicals, propellants –fire crackers.	4
IV	**LAB SAFETY & ANALYTICAL PRINCIPLES**		**18**
	8	Lab safety measurements: Awareness of material safety data sheet (MSDS), safe storage and handling of hazardous chemicals, simple first aids; electric shocks, fire, cut by glass and inhalation of poisonous gas, Accidents due to acids and alkalies, burns due to phenol and bromine, disposal of waste chemicals, disposal of sodium and broken mercury thermometer, - R and S phrases (elementary idea only), Personal protective Equipment (PPE)	6
	9	Atomic mass - Molecular mass - Mole concept – Molar volume - Oxidation and reduction – Equivalent mass. Methods of expressing concentration: Molality, molarity, normality, ppm, and mole fraction. Dilution formula, Theory of volumetric analysis – Acid-base, redox, and complexometric titrations: acid-base, redox, and complexometric indicators. Principles in the separation of cations in qualitative analysis - Applications of common ion effect and solubility product - Microanalysis and its advantages. Accuracy & Precision (mention only).	12
V	**PRACTICALS**		**30**
	10	1. **Laboratory Safety** - Importance of lab safety – Burns – Eye accidents – Cuts – Gas poisoning – Electric shocks –Treatment of fires – First Aid and Treatment of Fires- Precautions and preventive measures. 2. **Volumetric Analysis (Any 8 experiments)** • Preparation of standard solutions. • Neutralization Titrations (i) Strong acid – strong base (ii) Weak acid – strong base (iii) Strong acid – weak base • Redox Titrations Permanganometry: 1. Estimation of oxalic acid. 2. Estimation of Fe^{2+}/$FeSO_4.7H_2O$/Mohr's salt. (**Make sure that for students opting chemistry as second minor, the experiments are not overlapping with first minor)**	15
	11	3. **Open-ended experiments (Any 3).** a. Determination of hardness of water. b. Iodimetry and Iodometry: Estimation of Iodine/copper/ chromium. c. Determination of acetic acid content in vinegar by titration with NaOH.	15

		d. Determination of alkali content in antacid tablets by titration with HCl. e. Determination of available chlorine in bleaching powder. **(Other related experiments suggested by the teacher may be conducted)**	

References:

1. C.N.R.Rao, *University General Chemistry*, MacMillan India (Ltd.)
2. Shashi Chowla; *Engineering Chemistry*, Danpat Rai Publication.
3. B.K. Sharma; *Industrial Chemistry*. Goel Publishing House, Meerut, 2003.
4. Singh, K., *Chemistry in Daily Life;* Prentice Hall of India, New Delhi, 2008.
5. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004.
6. 4. J. D. Lee, *Concise Inorganic Chemistry*, 5th edn., Blackwell Science, London, 2010.
7. B.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
8. Satya Prakash, *Advanced Inorganic Chemistry*, Volume 1, 5th Edition, S. Chand and Sons, New Delhi, 2012.
9. J. Mendham, R.C. Denney, J. D. Barnes and M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, Noida, 2013.
10. R. Gopalan, *Inorganic Chemistry for Undergraduates*, Universities Press, Hyderabad, 2009.
11. *Vogels Textbook of Quantitative Chemical Analysis*, 6thEdn., Pearson Education Ltd.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Provide a comprehensive understanding of the scientific method and the evolution of chemistry from ancient speculation to modern principles.	R, U	PSO – 3,4,5
CO-2	Explore the interdisciplinary nature of chemistry and its pivotal role as a central science, fostering critical thinking and interdisciplinary problem-solving skills.	U, An	PSO –3,4
CO-3	Realize the groundbreaking contributions of renowned scientists, nurturing a more inclusive understanding of the field's history and encouraging diversity in scientific pursuits.	An. Ap	PSO –3,4
CO-4	Develop a heightened awareness of chemical safety in everyday life and the importance of responsible chemical usage.	U, Ap	PSO – 1,2,3,4
CO-5	Develop a comprehensive understanding of laboratory safety measures, leading to a safe and responsible laboratory	Ap	PSO – 1,2,3,4

	environment.		
CO-6	Master key concepts in chemistry, enabling to perform accurate and precise chemical analyses and experiments effectively.	An	PSO – 1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: GENERAL CHEMISTRY I

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6,8 PSO –3,4,5	R, U	M, F	L	-
2	CO-2	PO-1,6,8 PSO –3,4	U, An	F, C	L	-
3	CO-3	PO-1,5,6,8 PSO –3,4	An. Ap	M, F	L	-
4	CO-4	PO-1,8 PSO –1,2,3,4	U, Ap	F, C	L	-
5	CO-5	PO-1,6 PSO –1,2,3,4	Ap	F, C, P	L	-
6	CO-6	PO-1,2,6 PSO –1,2,3,4,5	An	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	-	1	1	1	1	-	-	-	-	1	-	2
CO 2	-	-	1	1	-	1	-	-	-	-	1	-	2
CO 3	-	-	1	1	-	1	-	-	-	1	1	-	2
CO 4	1	1	3	2	-	1	-	-	-	-		-	2
CO 5	2	2	3	2	-	1	-	-	-	-	2	-	-
CO 6	2	2	3	3	2	2	-	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5	✓			✓
CO 6	✓			✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1MDCCHE100**				
Course Title	**FUNDAMENTAL ASPECTS OF ENVIRONMENTAL CHEMISTRY**				
Type of Course	MDC				
Semester	1				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	Includes a brief introduction of environmental components, different types of pollution and some major environmental disasters.				

Detailed Syllabus:

Module	Unit	Content FUNDAMENTAL ASPECTS OF ENVIRONMENTAL CHEMISTRY	45 Hrs
I		**BASIC CONCEPTS OF ENVIRONMENT**	**9**
	1	Types of Environments - Biotic and Abiotic, Environmental segments- Lithosphere, Hydrosphere, Biosphere and Atmosphere.	3
	2	Layers of Lithosphere, Layers of Atmosphere- Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.	3
	3	Meaning of Ecology - Structure and Function of Ecosystem- Producers, Consumers, Decomposers.	2
	4	Ecological Succession- Food Chain and Ecological Pyramids.	1
II		**AIR POLLUTION**	**6**
	5	Pollution, Pollutants and its Classification, Contaminants.	2
	6	Air Pollution - Types of Gaseous Air pollutants-CO, CO_2, NO, NO_2, SO_2, SO_3, Smog - Sources and Effects on Environment.	2
	7	Consequences of Air pollution - Global warming, Greenhouse effect, Acid rain and Importance of Ozone layer.	2
III		**WATER & SOIL POLLUTION**	**12**
	8	Water Quality Parameters- Dissolved Oxygen, BOD, COD, pH, Turbidity, Conductivity, Salinity (Qualitative idea only), Eutrophication.	3
	9	Major Water pollutants – Industrial Wastes, Sewage, Agricultural Pollutants, Radioactive Wastes, Detergents - Sources and Effects.	3

	10	Treatment of Waste Water- Filtration using Activated Charcoal and Ion Exchange Resins, Electrodialysis and Reverse osmosis	3
	11	Composition of soil- Inorganic and Organic Components in Soil- Micro and Macro nutrients,	3
	12	Soil pollutants - Industrial Wastes, Domestic Wastes, Agricultural Wastes and Radioactive Wastes - Sources and Effects.	3
	13	Solid Waste Management - Land Filling, Recycling, Incineration and Composting.	3
IV	**ENVIRONMENTAL DISASTERS**		**9**
	14	Definition and types of disasters – Natural and Manmade.	2
	15	Disaster management - Mitigation, Preparedness, Response and Recovery.	3
	16	Major environmental disasters - Three Miles Island accident, Endosulfan tragedy in Kerala, Chernobyl Incident, Minamata disease.	4
V	**OPEN ENDED MODULE:**		**9**
	17	Case Studies, Debates, Simulation Games, local field Trips, Project-Based Learning, Artistic Expression, Community Engagement, Critical Thinking Exercises etc. **(Or any other activities may be suggested by the teacher)**	

References

1. A.K. De, "*Environmental Chemistry*"
2. H.M. Saxena, "*Environmental Geography*".
3. G.W. Vanloon, S. J. Duffy, "*Environmental Chemistry – a global perspective*".
4. P.K. Gupta, "*Methods in Environmental Analysis Water, Soil and Air*".
5. V.P. Kudesia, "*Environmental Chemistry*".
6. G.S. Sodhi, "*Fundamental Concepts of Environmental Chemistry*".
7. V Subramanian, "*A Text Book of Environmental Chemistry*", Wiley 2020.
8. C. Baird and M. Cann, "*Environmental Chemistry*", W.H. Freeman and Company, 2012.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the structure and composition of the atmosphere.	U	PSO-1,2,3
CO-2	Observe, realise and enlist the causes of air pollution.	R, U	PSO-1,2,3

CO-3	Understand the qualities of water, identify the causes and effects of water pollution and acquire knowledge of waste water treatment.	U, R	PSO-1,2,3,4
CO-4	Acquire a basic knowledge of Soil Pollution	U, Ap	PSO-1,2,3,4
CO-5	Review major environmental disasters	R, An	PSO-1,2,3
CO-6	Gain a holistic understanding of pollution and develop skills to address it	U, An	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U	F, C, M	L	-
2	CO-2	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
3	CO-3	PO-1,6 PSO-1,2,3,4	U, R	F, C	L	-
4	CO-4	PO-1,6 PSO-1,2,3,4	U, Ap	F, C	L	-
5	CO-5	PO-1,6 PSO-1,2,3	R, An	F, C	L	-
6	CO-6	PO-1,2,3,4,5,6,8 PSO-1,2,3,4,5	U, An	F, C, P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8

CO 1	2	1	2	-	-	1	-	-	-	-	2	-	-
CO 2	1	2	3	-	-	1	-	-	-	-	2	-	-
CO 3	1	1	1	1	-	1	-	-	-	-	2	-	-
CO 4	1	1	1	1	-	1	-	-	-	-	2	-	-
CO 5	1	1	1	-	-	1	-	-	-	-	2	-	-
CO 6	1	1	1	1	1	1	1	2	3	2	2	-	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓			✓
CO 6	✓	✓	✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK1MDCCHE101**				
Course Title	**POLYMERS AND BIOPOLYMERS**				
Type of Course	**MDC**				
Semester	I				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	This course provides a comprehensive understanding of the fundamental principles of polymer chemistry and a brief idea of biopolymers.				

Detailed Syllabus:

Module	Unit	Content POLYMERS AND BIOPOLYMERS	45 Hrs
I	**BASIC PRINCIPLES OF POLYMERS**		**6**
	1	General Introduction to Polymers: Macro Molecules, Oligomers, Polymers, Degree of Polymerisation, Functionality.	2
	2	Classification of Polymer: Origin, Structure, Synthesis, Molecular forces.	1
	3	Polymer Synthesis- Synthesis of Copolymers, Block-Polymers, Polyesters, Poly Olefins, Polyamides, Polycarbonates.	2
	4	Chemistry of Polymerization- Addition polymerization and Condensation polymerization.	1
II	**COMMERCIAL POLYMERS**		**6**
	5	Commercially important polymers and their applications: Poly ethylene, Polypropylene, Polystyrene, Polyesters, Polyvinyl Chloride (PVC).	2
	6	Polymethylmethacrylate, Bakelite, Natural Rubber, Nylon-6, Nylon-66, Melamine, Terylene.	3
	7	Numbering of Plastics (Plastic identification code)	1
III	**RUBBER CHEMISTRY AND TECHNOLOGY**		**9**
	8	Natural and Synthetic Rubber: Historical review, Physical and Chemical Properties of Natural Rubber.	2
	9	Manufacture, Physical Properties and Applications of Synthetic Rubbers such as SBR, Nitrile, Butyl Rubber.	2

	10	EPDM, Neoprene, Vulcanisation of Rubber	1
	11	Rubber Processing- Miling, Mixing, Extrusion, Calendering, Molding and Curing (Explanation only)	2
	12	Rubber Reinforcement Technologies: Brief introduction, Role of Fillers and Reinforcements – Carbon Black.	2
IV	**BIOPOLYMERS**		**15**
	13	Introduction of biopolymers, Its classification on the basis of Type, Origin, Monomeric Units.	1
	14	Sources of Biopolymers, Need for Biopolymers.	1
	15	Introduction, functions and applications of Cellulose, Cotton, Wool, Silk,	2
	16	Paper, Rubber, Collagen, Lignin	2
	17	Structure and functions of bio-polymers: Proteins, Nucleic acid and Polysaccharides, Structure and applications of starch, shellac and cellulose.	4
	18	Biopolymers from Renewable Resources, Biocompatibility Requirements.	2
	19	Synthetic Biopolymers: Polylactic acid and its co-polymers, Aliphatic Polyesters, Polyethylene Oxides and its Copolymers.	3
V	**OPEN ENDED MODULE:**		**9**
	20	Seminar presentations, group discussions, debates, quizzes etc on a. Identification of polymer in a variety of common objects made from different types of polymers b. A specific biopolymer (e.g., cellulose, starch, chitin) and its application in various industries c. Recycling or upcycling of polymer waste d. Extraction of biopolymers from natural sources e. Biodegradation behavior of biopolymers in different environmental conditions (Or any other similar topics suggested by the teacher)	9

References

9. F.W. Billimeyer, "*Textbook of Polymer Science*", Wiley, India 2007.
10. V.R. Gowarikar, "*Polymer Science*", New Age International Publishers Ltd 2010.
11. P.J. Flory, "*Principles of Polymer Chemistry*", Asian Books Private Ltd 2006.
12. P. Ghosh, "*Polymer Science and Technology of Plastic and Rubber*", Tata McGraw Hill 2010.
13. M.P. Stevens, "*Polymer Chemistry*", Oxford University Press, Inc, 1990.
14. R. M Johnson, L Y Mwaikambo and N Tucker, "*Biopolymers*", Rapra Technology 2003.
15. S. Kalia and L. Avérous, "*Biopolymers: Biomedical and Environmental Applications*".

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the basic concepts of polymer chemistry	R, U	PSO-1,2,3
CO-2	Acquire Knowledge of the commercial applications of polymers in real world, its structure properties and relationship.	U	PSO-1,2,3,4
CO-3	Aware of the Natural rubber and synthetic rubbers and its processing.	U	PSO-1,2,3
CO-4	Understand the various types of biopolymers, its source, classification and applications.	R, U	PSO-1,2, 3
CO-5	Understand the basic concepts of natural and synthetic biopolymers.	U	PSO-1,2,3
CO-6	Critical evaluation of the environmental and societal implications of polymer usage	An, Ap, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: POLYMERS AND BIOPOLYMERS

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3,4	U	F, C	L	-
3	CO-3	PO-1,6 PSO-1,2,3	U	F, C	L	-
4	CO-4	PO-1,6 PSO-1,2	R, U	F, C, P	L	-
5	CO-5	PO-1,6 PSO-1,2,3	U	F, C	L	-

6	CO-6	PO-1,2,3,4,5,6,8 PSO-1,2,3,4,5	An, Ap, E	F, C, P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	1	1	-	-	1	-	-	-	-	2	-	-
CO 2	2	1	2	-	-	1	-	-	-	-	2	-	-
CO 3	2	2	2	-	-	1	-	-	-	-	2	-	-
CO 4	2	1	1	-	-	1	-	-	-	-	2	-	-
CO 5	2	2	1	-	-	1	-	-	-	-	2	-	-
CO 6	2	1	2	2	2	1	1	2	2	2	2	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4	✓			✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓

SEMESTER 2

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2DSCCHE100**				
Course Title	**ORGANIC CHEMISTRY I**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science 2. First semester FYUGP Chemistry DSC				
Course Summary	In organic chemistry, carbon's unique properties form the basis for classifying compounds, while functional groups dictate their reactivity. Understanding reaction mechanisms and stereochemistry is crucial for predicting and controlling organic reactions, alongside practical skills in qualitative analysis, allowing for the identification of functional groups and compounds.				

Detailed Syllabus:

Module	Unit	Content ORGANIC CHEMISTRY I	75 Hrs
I	**INTRODUCTION TO ORGANIC CHEMISTRY, NOMENCLATURE, FUNCTIONAL GROUPS AND REACTION NOTATIONS**		**12**
	1	Uniqueness of carbon: classification of organic compounds. Structure and Hybridization of alkanes alkenes and alkynes	2
	2	Functional groups (mention only), Review of basic rules of IUPAC nomenclature of organic compounds.	1
	3	Definition of reaction mechanism. Frontier molecular orbitals and organic reactions: Introduction to HOMO and LUMO, electrophiles and nucleophiles - classification based on frontier orbitals. Drawing of electron movements with arrows: curved arrow notation, Half headed and double headed arrows. Nature of bond fissions: Homolysis and heterolysis.	4
	4	Classification of reactions: addition, eliminations, substitution, rearrangement, oxidation, reduction and pericyclic reactions with one or 2 examples for each	5
II	**STEREOCHEMISTRY I**		**12**

	5	Introduction to structure and stereo chemistry of organic molecules: salient features of symmetry elements; role of principal axis, sigma plane, centre of symmetry, and alternating axis of symmetry in deciding chirality	3
	6	Representation of organic molecules: Fischer, Flying wedge, Sawhorse and Newman projection formulae. Interconversion between Fischer and three-dimensional formula	
	7	Conformational and configurational isomerism, dihedral angle and torsional strain, conformational analysis of acyclic systems: ethane and n-butane including energy diagrams.	3
	8	Conformations of cyclic molecules-3, 4, 5 and 6 membered rings-Baeyer's strain theory, Sache-Mohr theory of strainless rings, Pitzer strain	3
	9	Conformations of cyclohexane: chair, boat and skew boat forms, axial and equatorial bonds, ring flipping.	3
III	**STEREOCHEMISTRY II**		**12**
	10	Stereoisomerism: examples of compounds with one and two chiral centers, enantiomers and diastereomers, erythro and threo representations, meso compounds, prochiral faces, enantio and diastereotopicity	2
	11	Configurations and their specifications: absolute and relative configuration, configuration descriptors R/S and E/Z notations using Cahn-Ingold-Prelog rules, optical purity, enantio/diastereomeric excess	4
	12	Stereoisomerism in compounds without a stereogenic carbon: axial -, planar, helical chirality and assigning their configurational descriptors (R, S/M, P) –biphenyl, allenes, ansa and p-cyclophanes, helicines	3
	13	Racemic mixture, resolution, methods of resolution of racemic mixture	2
	14	Geometrical isomerism: cis-trans (maleic and fumaric acids), syn-anti (unsymmetrical ketoximes). Methods of distinguishing geometrical isomers using melting point, dipole moment, dehydration and cyclisation.	1
IV	**ORGANIC REACTION MECHANISM I**		**9**
	15	Electron displacement effects: Inductive effect, electromeric effect, mesomeric effect, resonance, hyperconjugative and steric effects.	2
	16	Acidity and basicity of organic compounds based on electron displacement effects: Acid characters of alcohols, phenols (phenol, o/m/p-cresols and o/m/p-nitro phenols) and carboxylic acids (aliphatic acids, mono, di, tri chloro acetic acids, Benzoic acid, o/m/p-nitro benzoic acids) and basic character of amines (aliphatic amines, aniline, N- & N, N-dimethyl aniline, o/m/p nitro anilines and o/m/p- toluedienes)	3

	17	Effects of hyperconjugative effect: stability of alkenes, alkylbenzenes, free radicals and carbocations. Dipole moment of propene and toluene	2
	18	Reaction intermediates: Carbocations, carbanions, carbenes and nitrenes (definition, hybridization, structure, classification, formation, stability and important reactions).	2
V	**ORGANIC CHEMISTRY PRACTICAL- ORGANIC QUALITATIVE ANALYSIS**		**30**
	19	Detection of Elements (Nitrogen, Sulphur and Halogen) using Lassaign's test	2
	20	Solubility Tests: a) Classification of compounds into water soluble/insoluble; b) Classification of compounds into ether soluble/insoluble c) Solubility in Na2CO3, d) Solubility in NaOH e) Solubility in HCl	2
	21	Tests for Aliphatic and Aromatic compounds: (i)Ignition test (ii)Nitration test	2
	22	Tests for saturated and unsaturated compounds: (i)Oxidation (ii) Bromination	2
	23	Tests to distinguish between following compounds: a) monocarboxylic acid and dicarboxylic acid; b) Primary, secondary and tertiary amines ; c) monoamide and diamide; e) Aldehyde and ketone ; f) Reducing and non-reducing sugars; g) monohydric phenols and dihydric phenols	3
	24	Reactions of common functional groups using known organic compounds.	4
	25	Systematic qualitative analysis with a view to characterization of the following functional groups a) Halo compounds: chlorobenzene, benzyl chloride; b) Phenols: phenol, o, m , p -cresols, naphthols, resorcinol ; c) Aldehydes and ketones: benzaldehyde, acetophenone, benzophenone; d) 4 Carboxylic acids: benzoic, phthalic, cinnamic and salicylic acids; e) Esters: ethyl benzoate, methyl salicylate; f) Amides: benzamide, urea; g) Anilines: aniline, o,m, p - toluidines, dimethylaniline; h) Nitro compounds: nitrobenzene, o- & p- nitro toluene; i) Poly nuclear hydrocarbons: naphthalene, anthracene; j) Reducing and non-reducing sugars: glucose and sucrose	15

References:

Text books:

1. J.Clayden, N.Greeves and S.Warren, Organic Chemistry, Oxford University Press, New York.

2. Carey, Francis A., Giuliano, Robert M. Organic Chemistry. United Kingdom: McGraw-Hill, 2011.
3. P. S. Kalsi, Stereochemistry Conformation and Mechanism. India: New Age International (P) Limited, 2008.
4. D., Stereochemistry of Organic Compounds: Principles and Applications, New Age International Publishers, New Delhi
5. John McMurry, Organic Chemistry, Brooks/Cole Cengage Learning, 2012
6. A.Bahl and B.S.Bahl, Advanced Organic Chemistry, S.Chand & Company, New Delhi.
7. L.G.Wade Jr, Organic Chemistry, Pearson Education, New Delhi.
8. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, A textbook of Organic Chemisty, Vikas Publishing House (Pvt) Ltd., New Delhi..
9. S.C.Sharma and M.K.Jain, Modern Organic Chemistry, Vishal Publishing Company, New Delhi.
10. I L Finar, "Organic Chemistry" Vol – 1, 5th Edition, Pearson Education, NewDelhi

For Further Reading

1. R.T. Morrison, R.N.Boyd. Organic Chemistry, Pearson Education, New Delhi.
2. P.Y.Bruice, Essential Organic Chemisty, Pearson Education, New Delhi.
3. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, Pearson Education, New Delhi.
4. G.M. Louden, Organic Chemistry, Oxford University Press, New York.
5. E.L.Eliel, Stereochemistry of Carbon compounds, Tata McGraw Hill Publishing House, New Delhi.
6. J.March, Advanced Organic Chemistry, John Wiley & Sons., NY.
7. S.M.Mukerji and S.P.Singh, Reaction Mechanism in Organic Chemistry, McMillan Publishers.
8. R.O.C. Norman and J.M.Coxon, Principles of Organic Synthesis, CRC Press.

For Practicals

<u>Textbooks</u>

1. A.I.Vogel, "A text book of Qualitative Analysis including semi micro methods" Longmans.
2. V.V.Ramanujam, "Semi micro Qualitative Analysis"
3. E.S.Gilreath "Qualitative Analysis using semi micro method" Mc Graw Hill
4. A.I.Vogel, "A text book of Qualitative Inorganic Analysis" Longmans
5. A.I.Vogel, "Elementary Practical Organic Chemistry" Longmans
6. J B Yadav,Advanced Practical Physical Chemistry, Goel ,Publishing House

<u>For Further Reading</u>

1. Day and Raman, "Laboratory Manual of Organic Chemistry".
2. B.Viswanathan and P.S Raghavan , "Practical Physical Chemistry" 2005 Edn. Viva Books (Pvt.Ltd)
3. F.G Mann and B.C Saunders, "Practical Organic Chemistry" 4th Edn, Orient Longmann
4. N.K.,Vishnu, "Advanced practical organic chemistry" Vikas publishing house, New Delhi

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Recall the fundamentals of organic chemistry including nomenclature, functional groups, notation and classification	U	PSO-1
CO-2	Understand various conformational isomerism exhibited by organic molecules	R, U	PSO-1
CO-3	Develop curiosity in applying CIP rules to predict configuration of organic molecules	U,An	PSO-1,2,3
CO-4	Identify various electron displacement effects, reaction intermediates and reaction mechanism of substitution and elimination reactions	Ap, An	PSO-1,2
CO-5	Practice systematic scientific procedure for the qualitative analysis of organic compounds	U, Ap, C	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ORGANIC CHEMISTRY 1

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO-1	PSO-1	U	F	L	-
2	CO-2	PSO-1	R, U	F	L	-
3	CO-3	PSO-1,2,3	U, An	C	L	-
4	CO-4	PSO-1,2	Ap, An	F,C	L	-
5	CO-5	PSO-1,2,3,4,5	U, Ap, C	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8

CO 1	2	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	2	2	-	-	-	-	-	-
CO 3	2	3	1	-	-	2	2	-	-	-	-	-	-
CO 4	3	3	-	-	-	2	2	-	-	-	-	-	-
CO 5	2	2	2	3	3	2	2	3	-	-	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5	✓	✓	✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2DSCCHE101**				
Course Title	**FUNDAMENTALS OF CHEMISTRY II**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge 2. Any first semester DSC (chemistry) offered by UoK (preferable)				
Course Summary	The course includes subjects in petrochemicals, catalysis, photochemistry, metallurgy, and nanomaterials and basic principles in the gaseous state. Students have practical experience in analytical procedures and acquire critical thinking skills through open-ended experiments such as gravimetric analysis and determination of physical constants, focused on inorganic qualitative analysis.				

Detailed Syllabus:

Module	Unit	Contents	Hrs
	FUNDAMENTALS OF CHEMISTRY II		**75**
I	**GASEOUS STATE**		**9**
	1	Maxwell's distribution of molecular velocities (No derivation), average, most probable and rms velocities	3
	2	Collision number and collision frequency, mean free path,	1
	3	Deviation of gases from ideal behaviour – Boyle temperature, derivation of vander waals constants and critical constants	2
	4	Law of corresponding states – reduced equation of state, Joule Thomson effect, liquefaction of gases – Linde's and Claude's processes.	3
II	**PETROCHEMICALS AND ALTERNATE SOURCES**		**9**
	5	Petrochemicals: - Introduction, Natural gas - CNG, LNG and LPG. Coal: classification based on carbon content- Carbonisation of coal	2
	6	Crude oil: constitution and distillation, composition and uses of important Fractions Ignition point, flash point and octane number- cracking Usage and depletion of petroleum products.	3
	7	Need for alternative fuel and Green Chemistry approaches for sustainable development:	1

	8	Introduction, Solar energy harvesting- photosynthesis Photo voltaic cell, conventional solar cells, nano structured solar cells, Hydrogen as the future fuel	3
III	**CRYSTALLINE STATE**		**9**
	9	Isotropy and anisotropy – symmetry elements in crystals – the seven crystal systems. Miller indices, Bravais lattices, primitive, bcc and hcc of cubic crystals	3
	10	Representation of lattice planes of simple cubic crystal - Density from cubic lattice dimension – calculation of Avogadro number	2
	11	Bragg equation, diffraction of X-rays by crystals – single crystal and powder method. Detailed study of structures of NaCI and KCl crystals.	4
IV	**METALLURGY & CHEMISTRY OF NANOMATERIALS**		**18**
	12	General principles of occurrence and extraction of metals, Concentration of ores- roasting, calcination and smelting	3
	13	General Methods of extracting metal from concentrated ore, examples Electro metallurgy-Metallurgy of Aluminium, Sodium-Pyrometallurgy	3
	14	Refining of crude metals: Distillation, Liquation, electrolytic and zone refining Chromatographic techniques and vapour phase refining (Mond's process and Van Arkel process) Metallurgy of titanium, cobalt, nickel, thorium and uranium	3
	15	Evolution of Nano science – Historical aspects – preparations containing nano gold in traditional medicine, Lycurgus cup – Faraday's divided metal etc. Nanosystems in nature.	2
	16	Preparation of Nano particles – Top – down approach and bottom – top approach, Sol – gel synthesis, colloidal precipitations, Co-precipitation, combustion technique.	3
	17	Properties of nano particles: optical, magnetic and mechanical properties.	2
	18	Applications of nano materials in electronics, robotics, computers, sensors, mobile electronic devices, medical applications (use Au, Ag, ZnO and ZnO2 as examples)	2
V	**PRACTICALS: INORGANIC QUALITATIVE ANALYSIS**		**30**
	19	**I. REACTIONS OF THE FOLLOWING CATIONS:** Hg^{+}, Pb^{2+}, Ag^{+}, Hg^{2+}, Bi^{3+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}, Sn^{4+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Mn^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+} and NH_4^{+}. **II. SYSTEMATIC ANALYSIS OF TWO CATIONS IN A MIXTURE** The cations must be provided in solutions. A student must analyze **at least 8 mixtures** containing two cations each.	15
	20	**OPEN ENDED PRACTICALS: (Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** **III. GRAVIMETRIC ANALYSIS** a. Estimation of water of hydration in barium chloride crystals.	15

		b. Estimation of barium chloride solution. **IV. DETERMINATION PHYSICAL CONSTANTS** a. Determination of boiling points of common solvents (b.pt range 100°C - 130°C b. Determination of melting points of organic substances (m.pt range 100°C - 130°C)	

References

1. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn Vishal Publishing Co. New Delhi.
2. J E Huheey, E A Keiter, R L Keiter, O K Medhi, *Inorganic Chemistry*, 4th Edn. Pearson.
3. F A Cotton and Wilkinson, *Advanced Inorganic Chemistry*, John Wiley, New York.
4. P L Soni, O P Dharmarsha, U N Dash, *Textbook of Physical Chemistry*, 23rd Edn, Sultan Chand & Sons, New Delhi, 2011.
5. Gurudeep Raj, *Advanced physical chemistry*.
6. F Daniel and R A Alberty, *Physical chemistry*.
7. T Pradeep, *A Text book of Nanoscience and Nanotechnology*, Mc Graw Hill, New Delhi.
8. J V. V.Ramanujam, "*Semi micro Qualitative Analysis*"
9. E. S. Gilreath "*Qualitative Analysis using semi micro method*" Mc Graw Hill.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the effect of temperature on molecular velocities of gases and equation for real gases	U	PSO-1
CO 2	Apply the principles in liquefaction of gases	Ap	PSO-2
CO 3	Apply the importance of energy and environment conservation	Ap	PSO-3
CO 4	Get insight to the emerging area of nano and advanced materials	U	PSO-3
CO 5	Apply the principles of physical Chemistry in Catalysis and photochemistry	Ap	PSO-4
CO 6	Apply the basic principles in qualitative analysis and identify cation and anion.	Ap	PSO-2 &4
CO 7	Discuss the basic principles of metallurgy	U	PSO-1 &2
CO 8	Demonstrate the extraction of some metals used in daily life	Ap	PSO-2&4

CO 9	Apply the principles in analytical chemistry to identify the cations	Ap	PSO-5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FUNDAMENTALS OF CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1 PSO-1	U	F, C	T	
2	CO 2	PO-2 PSO-2	Ap	P	T	
3	CO 3	PO-8 PSO-3	Ap	C	T	
4	CO 4	PO-3 PSO-3	U	C, M	T	
5	CO 5	PO-2 PSO-4	Ap	C	T	
6	CO 6	PO-6 PSO-2 &4	Ap	P		P
7	CO 7	PO-2& 6 PSO-1 &2	U	P		P
8	CO 8	PO-2 PSO-2&4	Ap	P		P
9	CO 9	PO-3 PSO-5	Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	-	-	2	-	-	-	-	-	-	-

CO 2	-	2	-	-	-	-	2	-	-	-	-	-	-
CO 3	-	-	3	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	3	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	3	-	-	3	-	-	-	-	-	-
CO 6	-	2	-	2	-	-	-	-	-	-	2	-	-
CO 7	2	2	-	-	-	-	2	-	-	-	2	-	-
CO 8	-	2	-	2	-	-	2	-	-	-	-	-	-
CO 9	-	-	-	-	3	-	-	2	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√			√
CO 5	√			√
CO 6	√			√
CO 7			√	
CO 8			√	
CO 9	√			√

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2DSCCHE102**				
Course Title	**ESSENTIALS OF INORGANIC CHEMISTRY**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	3. Higher secondary level science knowledge 4. First semester DSC (chemistry) offered by UoK (preferable)				
Course Summary	This course delves into metallurgy, crystalline state, radioactivity, nuclear chemistry, chemical cycles, group properties, and qualitative inorganic analysis. Students gain theoretical knowledge and practical skills necessary for understanding and analyzing inorganic materials and processes.				

Detailed Syllabus:

Module	Unit	Content	Hrs
	ESSENTIALS OF INORGANIC CHEMISTRY		**75**
I	**METALLURGY**		**9**
	1	Occurrence of metals, General principles of extraction of metals from their ores: Concentration of ores- roasting, calcinations and smelting	3
	2	General methods of extracting metal from concentrated ore Electrometallurgy and Pyrometallurgy Refining of metals: electrolytic and zone refining only.	3
	3	Metallurgy of Titanium, Iron, cobalt, Nickel, Thorium, Uranium Extraction of lanthanides	3
II	**CRYSTALLINE STATE**		**9**
	4	Isotropy and anisotropy – symmetry elements in crystals – seven crystal systems	2
	5	Miller indices, Bravais lattices, primitive, bcc and fcc lattices of cubic crystals	2
	6	Bragg equation - diffraction of X rays by crystals – single crystal and powder method Detailed study of structure of NaCl and KCl crystals	3
	7	Liquid crystals, application and examples	2
III	**RADIOACTIVITY**		**9**
	8	Radioactive equilibrium (qualitative idea only)	1

	9	Detection of radio activity by Wilson's cloud chamber and Geiger Muller Scintillation counter – Units of radio activity – Curie and Rutherford	2
	10	Radio Carbon dating, Rock dating, Neutron activation analysis Applications in agriculture and medicine. A brief study of the biological effects of radiation such as pathological and genetic damage	2
	11	Dosimetry – Units – Rad, Gray, Roentgen. Ferrous and Ceric sulphate dosimeters	2
	12	Nuclear Chemistry – stability of Nucleus – n/p ratio, artificial transmutation and radio activity, mass defect, binding energy, atomic fission and fusion	2
IV	**CHEMICAL CYCLES, GROUP PROPERTIES, ACIDS, BASES AND BUFFERS**		**18**
	13	Carbon, Sulphur, Nitrogen, Phosphorous and hydrologic cycle	4
	14	Group properties (reactions) of anions in common minerals - Carbonate, Sulphate, Phosphate, Sulphides and Fluorides	3
	15	Classification of oxides – Acidic, Basic, Amphoteric and neutral	2
	16	Concepts of Acids and Bases, ionization of weak electrolytes.	3
	17	Influence of solvent on acid strength – leveling effect	2
	18	pH and its applications. Buffer solutions.	2
	19	Henderson equation	2
V	**PRACTICALS: INORGANIC QUALITATIVE ANALYSIS**		**30**
	20	**V. REACTIONS OF THE FOLLOWING CATIONS:** Hg^{+}, Pb^{2+}, Ag^{+}, Hg^{2+}, Bi^{3+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}, Sn^{4+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Mn^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+} and NH_4^{+}. **VI. SYSTEMATIC ANALYSIS OF TWO CATIONS IN A MIXTURE** The cations must be provided in solutions. A student must analyze **at least 8 mixtures** containing two cations each.	15
	21	**OPEN ENDED PRACTICALS: (Any 3 experiments are to be conducted - May be selected from the list or the teacher can add related experiments)** **VII. GRAVIMETRIC ANALYSIS** c. Estimation of water of hydration in barium chloride crystals. d. Estimation of barium chloride solution. **VIII. DETERMINATION PHYSICAL CONSTANTS** c. Determination of boiling points of common solvents (b.pt range 100°C - 130°C d. Determination of melting points of organic substances (m.pt range 100°C - 130°C)	15

References

a. B.R Puri, L R Sharma K C Kalia, *Principles of Inorganic Chemistry*, Sobhanlal Nagin Chand & Co. New Delhi
b. J D Lee, *Concise Inorganic Chemistry*, ELBS
c. D.A Skoog, D M West, F J, Holler, S R Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brookes/Cole, Thomson Learning, Inc, USA, 2004
d. Puri, Sharma and Pathania, *Principles of Physical Chemistry*
e. Gurudeep Raj, *Advanced physical chemistry*
f. Vogel's Text book of *Qualitative Analysis.*
g. J V. V.Ramanujam, "*Semi micro Qualitative Analysis*"
h. E. S. Gilreath "*Qualitative Analysis using semi micro method*" Mc Graw Hill.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss metallurgy and metallurgical processes	U	PSO-2
CO-2	Identify the extraction of different metals in daily life	Ap	PSO-1
CO3	Get an insight on crystal structure	Ap	PSO-1
CO 4	Draw and Make crystal models of NaCl & KCl crystals	C	PSO- 1&5
CO 5	Understand chemical cycles of Carbon, Sulphur, Nitrogen and Phosphorous	U	PSO-4
CO 6	Apply the basic principles in qualitative analysis and identify cation and anion	Ap	PSO-1&4
CO 7	Comprehend the properties of various anions, in particular, oxides	U	PSO2 &4
CO 8	Identify the principles in analytical chemistry for identifying the cations in different salts	An	PSO-5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ESSENTIALS OF INORGANIC CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)

1	CO-1	PO-1 PSO-2	U	C	L	
2	CO-2	PO-2 PSO-1	Ap	M	L	
3	CO3	PO-2 PSO-1	Ap	C	L	
4	CO 4	PO-3 PSO- 1&5	C	P	L	
5	CO 5	PO-1 PSO-4	U	F	L	
6	CO 6	PO-2&6 PSO-1&4	Ap	P		P
7	CO 7	PO-2&6 PSO2 &4	U	P		P
8	CO 8	PO-1 & 6 PSO-5	An	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	2	-	-	-	2	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	3	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	2	-	-	-	-	-	-
CO 4	2	-	-	-	2	-	-	2	-	-	-	-	-
CO 5	-	-	-	2	-	2	-	-	-	-	-	-	-
CO 6	2	-	-	2	-	-	2	-	-	-	3	-	-
CO 7	-	2	-	2	-	-	2	-	-	-	2	-	-
CO 8	-	-	-	-	3	3	-	-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√	√		√
CO 5	√	√		√
CO 6	√			√
CO 7			√	
CO 8	√			√

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2DSCCHE103**				
Course Title	**ESSENTIALS OF ORGANIC CHEMISTRY**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	5. Higher secondary level science knowledge 6. First semester DSC (chemistry) offered by UoK (preferable)				
Course Summary	The course covers the fundamentals of organic chemistry, stereochemistry, bioinorganic chemistry, medicinal chemistry, and practical organic qualitative analysis techniques. Students learn about the reactivity of organic compounds, stereochemical principles, biological roles of metals, pharmacognosy, and analytical methods for organic compound identification and purification.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		ESSENTIALS OF ORGANIC CHEMISTRY	**75**
I	**BASICS OF ORGANIC CHEMISTRY, SEPARATION AND PURIFICATION OF ORGANIC COMPOUNDS**		**9**
	1	Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications	2
	2	Dipole moment; Organic acids and bases; their relative strength.	1
	3	Homolytic and heterolytic fission with suitable examples. Curly arrow rules; Electrophiles and Nucleophiles; Nucleophilicity and basicity	2
	4	Types, shape and relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions - Addition, Elimination and Substitution reactions.	1
	5	General principles involved in the separation of precipitates, standards of purity, mixed melting point and boiling point	1
	6	Purification of solid organic compounds – extraction, use of immiscible solvents, solvent extraction, crystallization, fractional crystallization, sublimation, desiccants, vacuum drying. Purification of liquids – distillation, vacuum distillation, fractional distillation	2
II	**INTRODUCTION TO STEREOCHEMISTRY**		**9**

	7	Optical Isomerism: Chirality and elements of symmetry; DL notation and Enantiomers	2
	8	Optical isomerism in glyceraldehydes, lactic acid and tartaric acid	2
	9	Diastereoisomers and mesocompounds	1
	10	Cahn-Ingold-Prelog rules – R-S notations for optical isomers with one and two asymmetric carbon atoms	2
	11	Racemic mixture, resolution and methods of resolution	2
III	**CHROMATOGRAPHY**		**9**
	12	Outline study of Adsorption and partition chromatography	2
	13	Principle and applications of column, paper, thin layer, ion- exchange and gas chromatography	3
	14	Principle and applications of HPL, Rf and Rt value of various chromatographic techniques	2
	15	Paper chromatographic separation of amino acids and sugars Separation of a mixture of dyes by column chromatography. Principle and applications of TLC	2
IV	**PHYTOCHEMICALS, CRUDE DRUGS AND MEDICINAL CHEMISTRY**		**18**
	16	Pharmacognacy – Scope and importance, scheme for pharmacognotic studies of crude drugs	2
	17	Phytochemicals. Crude drugs: Morphological, pharmacological and chemical classification	2
	18	Processing of drugs: Method of preparation – decotion, maceration and infusion	2
	19	Methods of drug evaluation: Moisture content, volatile content, solubility, optical rotation, ash values and extracting, spectroscopic analysis, chromatographic method and foreign organic matter (Mention only)	4
	20	Carbohydrates, glycosides (saponin glycosides and cardiac glycosides), alkaloids (quinoline, isoquinoline, indole alkaloids and steroidal alkaloids) volatiles oils and phenols (Mention its sources, important compounds in each class and therapeutic importance)	4
	21	Chemo therapy- Drugs-Classification based on application. Elementary study of analgesics, antipyretics, antibiotics, antimalarials. sulphadrugs, mode of action of sulphadrugs. Synthesis of aspirin and paracetamol	4
V	**PRACTICALS: ORGANIC QUALITATIVE ANALYSIS**		**30**
	22	**Section A: Organic Qualitative Analysis (Any 5 compounds with different functional groups are compulsory)** Systematic analysis with a view to identify the organic compound (aromatic – aliphatic, saturated – unsaturated, detection of elements and detection of functional groups) – polynuclear hydrocarbons, alcohols, phenols, halogen compounds, nitro compounds, amino compounds, aldehydes, ketones, carboxylic acids, amides, urea, thiourea and esters. Only monofunctional compounds are to be given.	15

	23	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add experiments)** 1. Preparation of derivatives of above analysed organic compounds 2. Identification of Carbohydrates: Glucose, fructose, sucrose and starch. 3. TLC - Separation and identification- Determination of Rf value of o-and p-nitroanilines,o- and p-chloroanilines, p-chlorophenol and p-nitrophenol, p-chloroaniline and p–nitroaniline, benzil and o-nitroaniline or any two amino acids. 4. Preparation of Soap 5. Determination of total fatty acid present in given sample of soap. 6. Determination of total alkali present in given sample of soap 7. Preparation of liquid detergent 8. Preparation of solid detergents 9. Preparation of phenyl.	15

References

1. S M Khopkar, *Analytical chemistry*.
2. Gurdeep Chatwal, *Chemistry of natural products Vol. 1*.
3. P.L Soni, H.M. Chowla, *Text Book of Organic Chemistry*.
4. I.L. Finar, *Organic Chemistry Vol 1 & 2*.
5. Arun Bahl & B S Bahl, *Text Book of Organic Chemistry*.
6. *Elementary practical organic chemistry. Part 2: Qualitative Organic analysis.* von A. I. Vogel. Longmans, Green & Co. Ltd., London.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamentals of organic chemistry	U	PSO-1
CO 2	Apply the principles in purification of organic compounds	Ap	PSO-2
CO 3	Discuss the stereochemistry of organic compounds	U	PSO-1
CO 4	Get insight to the emerging area of phytochemistry	U	PSO-5
CO 5	Apply the principles of isolation of drugs	Ap	PSO-5
CO 6	Discuss the influence of bioinorganic compounds in our life	U	PSO-3
CO 7	Discuss the methods of preparation of drugs	U	PSO-4 & 5
CO 9	Demonstrate the extraction of medicines used in daily life	Ap	PSO-5

CO 10	Apply the principles in analytical chemistry to identify the organic compounds	Ap	PSO-2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ESSENTIALS OF ORGANIC CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1 PSO-1	U	C	L	
2	CO 2	PO-3 PSO-2	Ap	P	L	
3	CO 3	PO-1 PSO-1	U	C	L	
4	CO 4	PO-3 PSO-5	U	M	L	
5	CO 5	PO-3 PSO-5	Ap	P	L	
6	CO 6	PO-2 PSO-3	U	C	L	
7	CO 7	PO-1 PSO-4 & 5	U	P	L	
8	CO 8	PO-6 PSO-5	Ap	P		P
9	CO 9	PO-3 &6 PSO-2	Ap	M		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8

CO 1	2	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	-	2	-	-	-	-	-	2	-	-	-	-	-
CO 3	2	-	-	-	-	2	-		-	-	-	-	-
CO 4	-	-	-	-	2	-	-	2	-	-	-	-	-
CO 5	-	3	-	-	-	-	3	-	-	-	-	-	-
CO 6	-	-	3	-	-	-	2	-	-	-	-	-	-
CO 7	-	-	-	2	2	2	-	-	-	-	-	-	-
CO 8	-	-	-	-	3	-	-	-	-	-	3	-	-
CO 9	-	3	-	-		-	-	3	-	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√			√
CO 5	√			√
CO 6	√			√
CO 7	√			√
CO 8		√	√	
CO 9	√			√

University of Kerala

Discipline	**CHEMISTRY**				
Course Code	**UK2DSCCHE104**				
Course Title	**BIOORGANIC CHEMISTY & COLLOIDS**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 – 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	7. Higher secondary level science knowledge 8. First semester DSC (chemistry) offered by UoK (preferable)				
Course Summary	The course covers topics in organic chemistry, including carbohydrates, lipids, enzymes, vitamins, hormones, steroids, amino acids, proteins, nucleic acids, colloids, soaps, and detergents, along with practical skills in qualitative analysis and experimental techniques. This knowledge will prepare students for further studies in organic chemistry, biochemistry, and related fields.				

Detailed Syllabus:

Module	Unit	Content **BIOORGANIC CHEMISTY & COLLOIDS**	Hrs
I	**CARBOHYDRATES**		**9**
	1	Classification with examples. Preparation and properties of glucose, fructose and sucrose	2
	2	Cyclic structures and Haworth projections of glucose, fructose and maltose (ring size determination not expected).	2
	3	Mutarotation, epimerization, Conversion of glucose to fructose and vice versa.	3
	4	Structure of starch and cellulose (Elucidation not expected). Industrial applications of cellulose.	2
II	**LIPIDS, ENZYMES, VITAMINS, HORMONES AND STEROIDS**		**15**
	5	Lipids: Classification – Oils, fats and waxes (definition, structure, biological functions and examples). Hydrogenation and Rancidity - Acid value, Saponification value and Iodine value, biological functions of phospholipids and glycolipids	4
	6	Enzymes: Nomenclature, classification and characteristics. Mechanism of enzyme action. Theory of enzyme catalysis – Michaelis-Menten theory. Cofactors and coenzymes. Enzyme inhibitors. Uses of enzymes.	4

	7	Vitamins: Classification. Structure, biological functions and deficiency diseases of vitamins A, B1, B2, B3, B5, B6, B12 (structure not required), C and D.	4
	8	Hormones: Introduction. Steroid hormones, peptide hormones and amine hormones, examples, endocrine gland and biological functions (structure not required). Artificial hormones (elementary study only).	3
	9	Steroids: Introduction. Structure and functions of cholesterol. Elementary idea of HDL and LDL. Bile acids	3
III	**AMINOACIDS, PROTEINS AND NUCLEIC ACIDS**		**12**
	10	Amino acids: Classification – Zwitter ion formation and isoelectric point-Synthesis of glycine, alanine, and phenyl alanine (any one method). Peptides - Peptide bond.	4
	11	Proteins: Classification of proteins – Primary, secondary and tertiary structure of proteins -– Denaturation of proteins – Tests for proteins.	3
	12	Nucleic acids: Structure of pentose sugar, nitrogenous base, nucleoside and nucleotide – Double-helical structure of DNA – Differences between DNA and RNA.	2
	13	Biological Functions of DNA – Replication and protein biosynthesis. Transcription and Translation. Genetic code. (Elementary idea only)	3
IV	**COLLOIDS, SOAP & DETERGENTS**		**9**
	14	Introduction, dispersed phase, dispersion medium, classification, multi molecular, macromolecular and associated colloids.	2
	15	Preparation - condensation and dispersion methods, purification - dialysis and ultra filtration	2
		Properties of colloidal solution- optical, kinetic and electrical properties, coagulation, Hardy-Schultz rule, protective colloid	2
	16	Applications of colloidal systems	1
	17	Soaps and Detergents: Soaps – Types of soaps. Cleansing action of soaps.	1
	18	Synthetic detergents - Classification. Comparison between soaps and detergents. Environmental aspects.	1
V	**PRACTICALS**		
	19	**Section A: Organic Qualitative Analysis (Any 5 compounds with different functional groups are compulsory)** Systematic analysis with a view to identify the organic compound (aromatic – aliphatic, saturated – unsaturated, detection of elements and detection of functional groups) – polynuclear hydrocarbons, alcohols, phenols, halogen compounds, nitro compounds, amino compounds, aldehydes, ketones, carboxylic acids, amides, urea, thiourea and esters. Only monofunctional compounds are to be given.	15
	20	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add experiments)** 10. Preparation of derivatives of above analysed organic compounds 11. Identification of Carbohydrates: Glucose, fructose, sucrose and starch.	15

		12. TLC - Separation and identification- Determination of Rf value of o-and p-nitroanilines,o- and p-chloroanilines, p-chlorophenol and p-nitrophenol, p-chloroaniline and p–nitroaniline, benzil and o-nitroaniline or any two amino acids. 13. Preparation of Soap 14. Determination of total fatty acid present in given sample of soap. 15. Determination of total alkali present in given sample of soap 16. Preparation of liquid detergent 17. Preparation of solid detergents 18. Preparation of phenyl.	

References:

1. *Essential Organic Chemistry,* P.Y. Bruice, 1st Edition, Pearson Education, New Delhi.
2. *Organic Chemistry Vol. I & II,* I.L. Finar, Pearson Education, New Delhi.
3. *A Textbook of Organic Chemistry,* K.S. Tewari, N.K., Vishnoi and S.N. Mehrotra, Vikas Publishing House (P) Ltd., New Delhi.
4. *Modern Organic Chemistry,* M.K. Jain, S.C. Sharma, Vishal Publishing Co.
5. *Advanced Organic Chemistry*, A. Bahl and B.S. Bahl, S. Chand & Company, New Delhi.
6. *Biochemistry*, Rastogi, Tata Mc Graw – Hill Publication.
7. *Fundamentals of Biochemistry,* A.C. Deb, New Central Book Agency.
8. *Chemistry of Natural Products,* Bhat S.V., Nagasampagi, B.A. & Sivakumar M. Narosa.
9. *Vogel's Textbook of Practical Organic Chemistry,* Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R. Pearson Education.
10. *Practical Organic Chemistry,* Mann, F.G.; Saunders, B.C. Pearson Education, 2009.
11. *Comprehensive Practical Organic Chemistry – Preparation and Quantitative Analysis,* Ahluwalia, V.K.; Aggarwal, R. Universities Press, 2000.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Attain an understanding of carbohydrate chemistry, equipping with knowledge applicable to fields such as biochemistry, nutrition and food science.	U	PSO-1&3
CO-2	Understand the basic ideas of lipid chemistry, enabling to apply in various fields such as nutrition, biochemistry and pharmaceuticals.	U	PSO-1&3
CO-3	Gain an understanding of enzyme kinetics and their significance in biological processes, biotechnology, and medicine.	U	PSO-2&3

CO-4	Equip with the basic ideas of biomolecules and prepare for further studies in biochemistry, molecular biology, and related fields.	Ap	PSO-2&3
CO-5	Basic understanding of colloidal chemistry to prepare for further studies in related fields, as well as for careers in industries where colloidal systems play a significant role.	U, Ap	PSO-2&3
CO-6	Proficiency in chemical tests to detect specific functional groups in organic compounds, to equip with essential skills for qualitative analysis in organic chemistry laboratories.	An, Ap	PSO-2&4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: BIOORGANIC CHEMISTY & COLLOIDS

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-2 PSO-1&3	U	C	L	
2	CO-2	PO-1 PSO-1&3	U	C, M	L	
3	CO-3	PO-3 PSO-2&3	U	C	L	
4	CO-4	PO-2 &3 PSO-2&3	Ap	C, M	L	
5	CO-5	PO-3 PSO-2&5	U, Ap	C, M	L	
6	CO-6	PO-2 &6 PSO-2&4	An, Ap	C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8

CO 1	3	-	3	-	-	-	3	-	-	-	-	-	-
CO 2	2	-	2	-	-	2	-	-	-	-	-	-	-
CO 3	-	3	3	-	-	-	-	3	-	-	-	-	-
CO 4	-	2	2	-	-	-	2	2	-	-	-	-	-
CO 5	-	2	-	-	2	-	2	-	-	-	2	-	-
CO 6	-	2	-	2	-	-	2	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√	√		√
CO 5	√		√	√
CO 6	√			√

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2DSCCHE105**				
Course Title	**BIOMOLECULES AND BIOPHYSICAL CHEMISTRY-I**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge 2. Any first semester DSC (chemistry) offered by UoK (preferable)				
Course Summary	The course covers the chemistry of carbohydrates, amino acids and proteins, heterocyclic and bio inorganic compounds, solutions & colloids, Acids, Bases & Buffers. Students learn about the, physical and chemical properties of different classes of biomolecules and their importance. They gain a detailed understanding of solutions of acids, bases, and buffer. Students also get an idea about the biologically important heterocyclic compounds				

Detailed Syllabus:

Module	Unit	Content BIOMOLECULES AND BIOPHYSICAL CHEMISTRY-I	Hrs 75
1	**CARBOHYDRATES**		**9**
	1	Classification, configuration of D & L glyceraldehydes. Structure of ribose, 2-deoxy ribose, glucose, fructose, mannose and galactose. Properties of glucose and fructose - due to functional groups - hydroxyl, aldehyde and ketone, action of acids and alkali on sugars, Reducing actions of sugars	3
	2	Pyranoside structures of glucose and fructose. Furanoside structure of fructose (structure elucidation not expected). Mutarotation and epimerization. Glycosides and amino sugars	2
	3	Structure and biological importance of disaccharides - sucrose, lactose, maltose and cellobiose. Inversion of sucrose.	2
	4	Structure and important properties of the following structural polysaccharides (cellulose, chitin, pectin) and storage polysaccharides (starch, inulin, glycogen), Glycosaminoglycans- heparin, hyaluronic acid.	2

II	**AMINO ACIDS AND PROTEINS**		**12**
	5	Amino acids -Classification and properties, Essential and non-essential amino acids, zwitter ion, isoelectric point	2
	6	Synthesis of amino acids - glycine, alanine and tryptophan. Polypeptides and proteins - peptide linkage. Peptide synthesis - Carbobenzoxy, Sheehan and solid phase synthesis	3
	7	Proteins -primary, secondary, tertiary and quarternary structure of proteins. Denaturation and colour reactions of proteins	3
	8	RNA and DNA – Structure of purines and pyrimidines, nucleosides, nucleotides, phosphodiester linkages.	2
	9	Hydrolysis of nucleoproteins, structure of nucleic acids. their biological role. Replication of DNA.	2
III	**SOLUTIONS, COLLOIDS, ACIDS, BASES & BUFFERS**		**15**
	14	Meaning of normality, molarity, molality, percentage solution, mole fractions, simple numerical problems from the above	2
	15	Fundamental principles of diffusion and osmosis, biological importance of osmosis. Isotonic, hypotonic and hypertonic solutions.	2
	16	Meaning of true solution, colloidal solution, and coarse suspension, distinction between lyophilic and lyophobic sols	1
	17	Fundamental study of Donnan equilibrium- application in biological system, membrane permeability, methods of preparation of colloidal solution, separation of colloidal solutions, elementary study of charge on colloids	3
	18	Tyndall effect, emulsion and emulsifying agents, application of colloidal chemistry.	1
	19	Dissociation of water, ionic product of water, concepts of pH, pOH, simple numerical problems of pH. Determination of pH using indicators, pH meter and theoretical calculations.	2
	20	Dissociation of weak acids and electrolytes, Bronsted and Lewis theory of acids and bases, Meaning of Ka and pKa values.	1
	21	Buffers: buffer action, buffers in biological system, Henderson -Hasselbach equation with derivation, simple numerical problems involving application of this equation.	3
IV	**HETEROCYCLIC AND BIO INORGANIC COMPOUNDS**		**9**
	10	Structure of furan, pyrrole, thiophene, 1,3-diazole, 1,3-thiozole, pyridine, 1,3-diazine, indole, quinoline, isoquinoline, purine and pyramidine bases (structure only), Aromaticity of five and six membered heterocyclics.	3
	11	Metalloporphyrins – cytochromes, chlorophyll, photosynthesis and respiration, haemoglobin and myoglobin, mechanism of O_2 – CO_2 transportation.	3
	12	Biological fixation of nitrogen , Carbon fixation and carbon cycle.	1
	13	Role of alkali and alkaline earth metals in biological systems Biological functions and toxicity of Cr, Mn, Ni, Cu, Se, Mo, Co ,Fe & Zn.(mention only)	2
V	**PRACTICAL- ORGANIC COMPOUND ANALYSIS**		**30**

	22	**Section A: Organic Qualitative Analysis (Any 5 compounds with different functional groups are compulsory)** Systematic analysis with a view to identify the organic compound (aromatic – aliphatic, saturated – unsaturated, detection of elements and detection of functional groups) – polynuclear hydrocarbons, alcohols, phenols, halogen compounds, nitro compounds, amino compounds, aldehydes, ketones, carboxylic acids, amides, urea, thiourea and esters. Only monofunctional compounds are to be given.	15
	23	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add experiments)** Preparation of derivatives of above analysed organic compounds Identification of Carbohydrates: Glucose, fructose, sucrose and starch. TLC - Separation and identification- Determination of Rf value of o-and p-nitroanilines, o- and p-chloroanilines, p-chlorophenol and p-nitrophenol, p-chloroaniline and p–nitroaniline, benzil and o-nitroaniline or any two amino acids.	15

References

1. Dr. U.Satyanarayana, Dr.U.Chakrapani, *Biochemistry*, Books and Allied (P) Ltd
2. J. L. Jain, Sunjay Jain, Nitin Jain, *Fundamentals of Biochemistry*, S.Chand & Co. Ltd.
3. RK Murray, DK Granner, PA Mayers, VW Rodwell, *Harper's Biochemistry*, Prentiace-Hall International Editions.
4. Sharma, Madan and Pahania, *Principles of Physical Chemistry*, Vishal Publishing Co.
5. J.D. Lee, *Concise Inorganic Chemistry*.
6. Puri, Sharma and Kalia, *"Inorganic Chemistry"*.
7. Arthur I. Vogel, B. S. Furniss, *Vogel's Textbook of practical organic chemistry*, 5th ed., Longman Scientific & Technical, London, 1996.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the chemistry and structure of biologically important carbohydrates	U	PSO-1&5
CO-2	Describe the synthesis of amino acids and polypeptides	Ap	PSO-2&5
CO3	Understand the structure of protein and nucleic acids	U	PSO-2&5
CO 4	Explain the role of chlorophyll, haemoglobin, myoglobin, and elements in biological functions	U	PSO-2&5
CO5	Discuss the classification of colloids and their	U	PSO-1&2

	synthesis and applications		
CO 6	Understand the role of acids, bases and buffers, and to prepare standard solutions.	U	PSO-4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: BIOMOLECULES AND BIOPHYSICAL CHEMISTRY-I

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO1	PO-2 PSO-1&5	U	C	L	
2	CO2	PO-1 PSO-2&5	Ap	C	L	
3	CO3	PO-1 PSO-2&5	U	F	L	
4	CO4	PO-1&2 PSO-2&5	U	C	L	
5	CO5	PO-1 &3 PSO-1&2	U	C, M	L	
6	CO6	PO-6 PSO-4	U	C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	-	2	-	2	-	-	-	-	-	-
CO 2	-	2	-	-	2	2	-	-	-	-	-	-	-
CO 3	-	2	-	-	2	2	-	-	-	-	-	-	-
CO 4	-	2	-	-	2	2	2	-	-	-	-	-	-
CO 5	2	2	-	-	-	2	-	2	-	-	-	-	-
CO 6	-	-	-	2	-	-	-	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√	√		√
CO 5	√			√
CO 6	√			√

University of Kerala

Discipline	**CHEMISTRY**				
Course Code	**UK2DSCCHE106**				
Course Title	**GENERAL CHEMISTRY II**				
Type of Course	**DSC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge 2. First semester DSC (chemistry) offered by UoK (preferable)				
Course Summary	This course provides an overview of nanoscience, green chemistry, biomolecules, environmental and fuel chemistry. Through understanding nano systems, green chemistry principles, biomolecule structures, environmental threats, and fuel sources, students will gain insights into the interdisciplinary nature of chemistry and its applications in addressing global challenges. Practical experiments complement theoretical learning, offering hands-on experience in chemical and environmental analysis.				

Detailed Syllabus:

Module	Unit	Content GENERAL CHEMISTRY II	Hrs 75
I	**INTRODUCTION TO NANO SCIENCE**		**9**
	1	Terminology. Scales of nano systems. Evolution of nanoscience- Historical aspects, preparations containing nano gold in traditional medicine. Lycurgus cup- Faraday's divided metal etc. Nano systems in nature.	3
	2	Different types of nanoparticles. Classification of nanomaterials based on dimension with examples for each 0D, 1D, and 2D. Carbon nanotubes, Types of Carbon nanotubes – SWCNT and MWCNT, important properties of carbon nanotubes and application of carbon nanotubes. fullerenes, grapheme - (basic concept only, no classification required) Applications of nanomaterials.	6
II	**GREEN CHEMISTRY**		**9**
	3	Role of Chemical Industries in polluting the Environment. Limitations of conventional waste management and pollution prevention-birth of green chemistry.	2

	4	Introduction to the principles of green chemistry atom economy calculation (simple reactions), Production of Ibuprofen-less hazardous chemical syntheses, designing safer chemicals	3
	5	Bhopal gas tragedy- new greener syntheses, safer solvents and auxiliaries ionic liquids-super critical fluids CO_2 and H_2O, advantages of SCFs	3
	6	Green chemistry practices in research, educational and commercial laboratories- lab safety signs introduction to micro scale experiments.	1
III	**CHEMISTRY OF BIOMOLECULES**		**9**
	7	Carbohydrates - Introduction - classification, structure, common examples and biological significance.	2
	8	Introduction to lipids - classification to fats, phospholipids, steroids, and waxes, properties and biological functions	2
	9	Amino acids – essential amino acids – peptide bond formations – proteins, introduction to primary, secondary, tertiary and quaternary structures, protein denaturation, enzymes.	3
	10	Introduction to nucleic acids: DNA and RNA structure, functions, and types	2
IV	**ENVIRONMENTAL CHEMISTRY, FUEL CHEMISTRY**		**18**
	11	Nature of environmental threats and role of chemistry. Greenhouse effect, ozone layer and its depletion.	4
	12	Water pollution: Various factors affecting purity of water, sewage water, industrial waste, agricultural pollution such as pesticides, fertilizers, detergents, treatment of industrial waste water using activated charcoal, synthetic resins, reverse osmosis, electrodialysis. -Dissolved oxygen-BOD, COD	5
	13	Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value. Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas — composition and uses. Uses of coal tar bases chemicals, requisites of a good metallurgical coke.	3
	14	Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications. Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.	4
	15	Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.	2
V	**PRACTICALS**		**30**
	16	**A. (Any 5 experiments)** 1. Determination of dissolved oxygen in water. 2. Determination of Chemical Oxygen Demand (COD) 3. Determination of Biological Oxygen Demand (BOD) 4. Percentage of available chlorine in bleaching powder. 5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).	15

		6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-). 7. Measurement of dissolved CO_2. 8. Study of some of the common bio-indicators of pollution. 9. Estimation of SPM in air samples. 10. Preparation of borax/ boric acid.	
	17	**B. Open-ended experiments (Any 3).** **(From the above list or other related experiments suggested by the teacher may be conducted)**	15

References:

1. V. S. Muraleedharan and A. Subramania, *Nanoscience and nanotechnology*, Ane Books Pvt. Ltd. New Delhi, 2009.
2. T. Pradeep, *Nano: The Essentials*, McGraw-Hill education, New Delhi,2006.
3. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley & Sons, 2003.
4. Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
5. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
6. Finar, I. L. *Organic Chemistry (Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry* 7th Ed., W. H.
8. Freeman. Girard, J.E, (2011), *Principles of Environmental Chemistry*, Jones & Bartlett India Pvt. Limited.
9. Sodhi, G.S. ((2013), *Fundamental Concepts of Environmental Chemistry*, Narosa
10. Jain, P.C. & Jain, M. *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
11. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).
12. Maria C Suros, Environmental Sampling and Analysis, CRC press, Taylor & Francis, 1997.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain a basic understanding of nanoscience and nanomaterials.	R	PSO-5
CO-2	Equip with the basic knowledge to apply green chemistry principles for sustainable and environmentally responsible chemical practices.	U, Ap	PSO-4
CO-3	Understand the structures, functions, and significance of biomolecules, enabling to know fundamental aspects of biochemistry and molecular biology	U	PSO-1

CO-4	Possess the knowledge on various environmental threats and gain basic ideas to develop sustainable solutions for various environmental challenges.	R, U	PSO-4
CO-5	Gain a basic understanding of energy sources, fuels, and lubricants, to analyze, select, and utilize appropriate resources for various applications.	U, An	PSO-4
CO-6	Develop essential laboratory skills, analytical techniques, and an understanding of environmental monitoring methods	Ap, C	PSO-2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: GENERAL CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1 PSO-5	R	C	L	
2	CO-2	PO-3 PSO-4	U, Ap	P	L	
3	CO-3	PO-2 PSO-1	U	C	L	
4	CO-4	PO-3 PSO-4	R, U	M	L	
5	CO-5	PO-3 PSO-4	U, An	M	L	
6	CO-6	PO-6 PSO-2	Ap, C	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	-	-	-	3	3	-	-	-	-	-	-	-

CO 2	-	-	-	2	-	-	-	2	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	2	-	-	-	2	-	-	-	-	-
CO 6	-	2	-	-	-	-	-	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√		√	√
CO 5	√			√
CO 6	√			√

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2MDCCHE100**				
Course Title	**CHEMISTRY IN EVERYDAY LIFE**				
Type of Course	**MDC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	Chemistry in Everyday Life provides a comprehensive understanding of how chemistry permeates various aspects of our daily life.				

Detailed Syllabus:

Module	Unit	Content	45 Hrs
I	**CHEMICALS IN DAILY LIFE**		**6**
	1	Chemicals and their role in Cleansing Agents - Soaps and detergents.	2
	2	Chemical and their role in Cosmetics - Tooth paste, Talcum powder, Moisturizer, Sun screen lotion, Lipstick Nail polish and Hair dye.	2
	3	Harmful effects of cosmetics. Herbal Cosmetics- Definition, Natural Ingredients Used- Aloe Vera, Turmeric, Henna, Amla, Neem, Clove	2
II	**CHEMISTRY IN AGRICULTURE**		**6**
	4	Fertilizers – Introduction, Types of Fertilizers - Natural, Synthetic, NPK Fertilizers.	2
	5	Excessive Use of Fertilizers and Its Impact on the Environment, Bio Fertilizers and Organic Manures.	2
	6	Pesticides – Introduction, Classification (Brief idea only) - Insecticides, Fungicides, Herbicides (Structures not needed).	1
	7	Excessive Use of Pesticides - Environmental Hazards. Bio Pesticides.	1
III	**CHEMISTRY OF BIOMOLECULES**		**6**
	8	Carbohydrates - Classification- Monosaccharides, Disaccharides, Oligosaccharides, Polysaccharides, Importance of Carbohydrates.	2
	9	Elementary idea of Amino acids, Peptide bond, Polypeptides, Proteins - Classification- Fibrous and Globular Proteins, Simple, Conjugate and Derived protein, Denaturation of protein.	2
	10	Vitamins – Classification, functions and deficiency diseases	1
	11	Enzymes, Hormones and Nucleic acids (Basic concept only)	2
IV	**DYES, PIGMENTS AND MEDICINES**		**18**

	12	Definition of Dye, Requirements of a Good Dye, Classification of Dyes based on Origin, Application and Chemical properties.	3
	13	Biomedical Uses of Dyes - Dyes Used in Formulations (Tablets, Capsules, Syrups etc), Biological Staining Agents (Methylene blue, Crystal violet and Safranin T) (structure not needed). Health and Environmental Hazards of Synthetic Dyes.	3
	14	Pigments - White pigments (White lead, ZnO, Lithopone, TiO_2), Blue, Red, Yellow and Green pigments.	3
	15	Medicines and Drugs, Sources of Drugs - Microbial, Plant, Marine and Synthetic.	2
	16	Classification of Drugs - Analgesics, Antipyretic, Antihistamines, Antacids, Antiseptics, Antibiotics, Anti fertility drugs, Antihypertensive Drugs with examples (Structure not needed)	3
	17	Psychotropic Drugs - Tranquilizers, Antidepressants and Stimulants with examples (Structures Not needed). Anti-Cancerous Drugs.	3
	18	Drug Addiction and Abuse, Prevention and Treatment.	1
V	**OPEN ENDED MODULE:**		**9**
	19	Seminar presentations, group discussions, debates, quizzes, case studies, local field visits etc on a. Importance of chemical safety and responsible usage in daily life b. Impact of specific chemicals (e.g., pesticides, fertilizers, pharmaceuticals) on the environment. c. Natural sources of dyes (e.g., turmeric, beetroot, spinach) and methods for extracting and synthesizing dyes from these sources. d. Extraction of DNA, proteins, or lipids from various sources such as fruits, vegetables, or even their own cells (e.g., buccal swabs). e. Natural compounds that have pesticidal properties, such as neem oil, and compare their effectiveness with synthetic pesticides. **(Or any other similar topics suggested by the teacher)**	

References

1. B. K.Sharma, "*Industrial Chemistry, 11th Edition*".
2. K.H. Buchel, *Chemistry of Pesticides*, John Wiley & Sons, New York, 1983.
3. S.P. Bhutani, "*Chemistry of Biomolecule*".
4. S.B. Bhat, B. A. Nagasampagi, S. Meenakshi, "*Natural Products*".
5. S. Banarjee, "*Biomolecules*".
6. D.R. Waring and G. Hallas, "*The Chemistry and Application of Dyes*",
7. D.E. Newton, "*Chemistry of Drugs*".
8. A. Kour, "*Medicinal Chemistry*".
9. Dr. R. Kumara, "*Introduction to Cosmetic Chemistry*"

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the components of commonly used cosmetics and their effects.	**U**	PSO-5
CO-2	Understand the uses of fertilizers and pesticides and their impact on environment.	**U, R**	PSO-1&5
CO-3	Acquire knowledge on biomolecules.	**R, U**	PSO-1&3
CO-4	Understand basic concepts of dyes and pigments	**R**	PSO-1&5
CO-5	Acquire knowledge of commonly used drugs	**U, R**	PSO-1&5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY IN EVERYDAY LIFE

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-3 PSO-5	U	C	L	
2	CO-2	PO-2&3 PSO-1&5	U, R	C, M	L	
3	CO-3	PO-1 PSO-1&3	R, U	C	L	
4	CO-4	PO-2&3 PSO-1&5	R	C	L	
5	CO-5	Po-1 &2 PSO-1&5	U, R	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	-	-	-	3	-	-	3	-	-	-	-	-
CO 2	2	-	-	-	2	-	2	2	-	-	-	-	-
CO 3	2	-	2	-	-	2	-	-	-	-	-	-	-
CO 4	2	-	-	-	2	-	2	2	-	-	-	-	-
CO 5	2	-	-	-	2	2	2	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√			√
CO 5	√		√	√

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK2MDCCHE101**				
Course Title	**FOOD CHEMISTRY**				
Type of Course	**MDC**				
Semester	2				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	This course provides a comprehensive understanding of the composition of food and a brief idea of food processing and packaging.				

Detailed Syllabus:

Module	Unit	Content FOOD CHEMISTRY	45 Hrs
I		**INTRODUCTION TO FOOD AND NUTRIENTS**	**6**
	1	Functions of Food, Nutrients in Food- Energy Yielding Nutrients and Protective Nutrients (Vitamins and Minerals).	1
	2	Carbohydrates- Classification- Monosaccharides, Disaccharides, Oligosaccharides, Polysaccharides, Importance of Carbohydrates in diet**.**	2
	3	Proteins-Classification- Fibrous and Globular Proteins, Simple, Conjugate and Derived Protein, Denaturation of Protein	1
	4	Vitamins- Classification, Sources, Functions and Deficiency Diseases- Vitamin A, Vitamin B1 and B2, Vitamin C, Vitamin D, Vitamin E and Vitamin K.	2
II		**FOOD ADDITIVES AND FOOD ADULTERATION**	**15**
	5	Food Colours- Permitted and Non-Permitted, Artificial Sweeteners, Flavour Enhancers, Stabilizers and Thickening Agents, Fat Emulsifiers, Flour Treatment Agents.	2
	6	Preservatives- Natural and Artificial Food Preservatives, Antioxidants, Nutritional Supplements, Food Safety and Standards Act.	2
	7	Nutrition - Measurement of Energy Value of Food, Calorific Value, Calorific Requirements.	2
	8	Digestion and Absorption of Food-Composition and Functions of Bile, Outline Study of Digestion and Absorption- Carbohydrates, Proteins and Fats.	2

	9	Modern Food Habits- An Introduction, Health Effects of Fast Food, Junk Food, Dehydrated Food and Instant Food.	2
	10	A Comparative Study of Traditional Food Habits and Modern Food Habits. Composition and Health Effects of Soft Drinks and Beverages.	2
	11	Common Adulterants in Different Foods and Their Health Effects and Detection- Milk, Ghee, Butter, Honey, Sweets, Chilli powder, Turmeric, Tea, Sugar and Salt, black pepper, Wheat and rice.	3
III		**DAIRY PRODUCTS**	**9**
	12	Milk, Composition of Milk - Water, Protein, Lactose and Fat, Nutritive Value of Milk.	2
	13	Condensed Milk – Definition, Composition and Nutritive Value. Standardised Milk, Homogenised Milk, Flavoured Milk, Vitaminised Milk, Toned Milk.	2
	14	Butter - Composition - Theory of Churning - Desibutter - Salted Butter. Ghee - Major Constituents - Rancidity, Prevention. Cream- Definition-Composition-Chemistry of Creaming Process.	3
	15	Milk powder - Definition - Making Milk powder - Drying Process, Quality Assurance – FSSAI, PFA, AGMARK	2
IV		**FOOD PROCESSING AND PACKAGING**	**6**
	16	Food Processing - Definition, Levels and Purpose	1
	17	Traditional and Modern Methods- Heat Treatment, Fermentation, Pickling, Smoking, Drying, Curing, Freezing, Pasteurization, Ultra Heat Treatment.	3
	18	Consequences of Food Processing, Packaging Materials - Hazards, Future Prospects of Food Package.	2
V		**OPEN ENDED MODULE:**	**9**
	19	Seminar presentations, group discussions, debates, quizzes, case studies, local field visits etc on a. Nutrition analysis of popular foods b. Food label investigation for food additives c. Dairy product development d. Food safety incidents e. Challenges on food packaging f. Experimental analysis for food adulteration (Or any other similar topics suggested by the teacher)	

References

1. B. Srilakshm, "*Food science, Seventh Edition*".
2. S. Manay, "*Food: Facts and Principles*".
3. S. Sehgal, "*A Laboratory Manual of Food Analysis*".
4. H.D. Belitz, W. Grosch and P. Schieberle, "*Food Chemistry*".

5. J.M. de Man, "*Principles of Food Chemistry*".
6. S. Suzanne Nielsen, "*Food Analysis*".
7. L. H. Meyer, "*Food Chemistry*".
8. M. Sethi, E. S. Rao, "*Food Science- Experiments and Applications*".
9. N. N. Potter, J. H. Hotchkiss, "*Food Science*."

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Identify the components of food.	**R, U**	PSO-2 &3
CO-2	Identify additives added to foods for various purposes.	**U**	PSO-4
CO-3	Acquire knowledge of adulteration and toxicity of food.	**R, Ap**	PSO-4
CO-4	Understand the various types of dairy products based on their composition.	**R, U**	PSO-5
CO-5	Understand the basic concepts of food processing and packaging.	**U**	PSO-2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FOOD CHEMISTRY

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-2 PSO-2 &3	R, U	C	L	
2	CO-2	PO-1 PSO-4	U	C, P	L	
3	CO-3	PO-3 PSO-4	R, Ap	C, P	L	
4	CO-4	PO-1 PSO-5	R, U	C	L	

5	CO-5	PO-3 PSO-2	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	2	2	-	-	-	2	-	-	-	-	-	-
CO 2	-	-	-	2	-	2	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	3	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	2	-	-	-
CO 5	-	2	-	-	-	-	-	2	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√	√		√
CO 5	√	√		√

SEMESTER 3

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSCCHE200**				
Course Title	**PHYSICAL CHEMISTRY I**				
Type of Course	**DSC**				
Semester	3				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge 2. Basic understanding of calculus is preferred.				
Course Summary	This physical chemistry course covers a broad range of topics including solid state, liquid state, gaseous state, dilute solutions, and colloids, providing students with a comprehensive understanding of the properties and behaviours of matter at various states and concentrations. Through theoretical principles and practical experiments, students gain insights these topics and to apply their knowledge to solve real-world problems.				

Detailed Syllabus:

Module	Unit	Content **PHYSICAL CHEMISTRY I**	Hrs 75
I	**SOLID STATE**		**9**
	1	Amorphous and Crystalline solids. Isotropy and anisotropy, size and shape of crystal, Interfacial angle, types of crystals: molecular crystals, ionic crystals, covalent crystals and metallic crystals- examples and properties.	2
	2	Symmetry of crystals- plane of symmetry, axis of symmetry, centre of symmetry (definitions and basic idea only), Seven basic crystal systems, Space lattice and unit cell, Bravais lattices, (unit cell parameters and examples of 14 Bravis lattices), close packing structures of cubic and orthorhombic space lattices.	2
	3	Law of constancy of interfacial angles, Laws of rational indices, Miller indices, Representation of lattice planes of cubic crystals, interplanar spacing in crystals, Determination of Avogadro number from crystallographic data	2
	4	X-ray diffraction studies of crystals, Bragg's equation – derivation and applications, Rotating crystal and powder method. Structure of NaCl and CsCl, Imperfections in crystals. Stoichiometric and	2

		Nonstoichiometric defects, point defects – Schottky and Frenkel defects, F-centre	
	5	Energy band theory of Conductor, Semiconductors and insulators, Glasses	1
II	**LIQUID STATE**		**9**
	6	Physical properties of liquids; vapour pressure, surface tension, viscosity, and Refractive Index and their determination. Factors affecting surface tension and viscosity, Interfacial tension, Surface active agent, Explanation of cleansing action of detergents.	3
	7	Determination of Surface tension- capillary rise and stalagmometer method Viscosity- Poiseuilles equation, Determination of viscosity- Ostwald's viscometer Refractive index determination by Abbe refractometer	3
	8	Liquid crystals- introduction, characterization of liquid crystals, Types –smectic, nematic and cholesteric liquid crystals- examples; Disc shaped liquid crystals, Polymer liquid crystals. uses of liquid crystals	3
III	**GASEOUS STATE**		**9**
	9	Ideal gas, Ideal gas equation, gas constant: values in different units ($JK^{-1}mol^{-1}$, L atm $K^{-1}mol^{-1}$, cal $K^{-1}mol^{-1}$) Dalton' Law of Partial pressure- Definition and mathematical expression. Postulates of Kinetic theory of Gases and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity; variation of viscosity with temperature and pressure.	2
	10	Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartitions of energy and degrees of freedom.	2
	11	Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases, Causes of deviation from ideal behaviour. Z-P plots of ideal gas and the real gases H_2, He, NH_3, CO and methane at 0°C, Z-P plots of N_2 at several temperatures.	2
	12	Vander Waals equation of state, its derivation and application in explaining real gas behaviour. Vander Waal's equation at low and high pressures and at high temperature.	1
	13	Law of corresponding states, liquefaction of gas, inversion temperature PV isotherm of Carbon dioxide, critical state, relation between critical constants and van der Waals constants, Correction factors, Experimental determination critical constants, Boyle temperature, Boyle temperature in terms of van der waal's constant. Virial equation of state and virial coefficients. (no derivations).	2
IV	**DILUTE SOLUTIONS AND COLLOIDS**		**18**

	14	Dilute solutions: Binary solutions, Concentration- Molarity, Molality, Normality and Mole fraction. (numerical problems)	2
	15	Raoult's Law for solutions of non-volatile solutes, vapour pressure of ideal solutions and relative lowering of vapour pressure.	1
	16	Colligative properties- lowering of vapour pressure; elevation of boiling point and depression in freezing point; molal elevation constant, molal depression constant, Thermodynamic derivation of ΔT; Osmosis and Osmotic pressure, van't Hoff equation; Isotonic, hypertonic and hypotonic solutions, Abnormal molecular mass and van't Hoff factor, Determination of degree of dissociation and association, Reverse osmosis (numerical problems).	4
	17	Experimental determination of molecular mass of solutes by cooling curve method, Rast's and Beckmann methods	2
	18	**Colloids:** Classification of colloids – Preparation of colloids	2
	19	Purification of colloids – dialysis, electrodialysis, hot dialysis, ultra filtration ultra centrifugation	2
	20	Kinetic, optical and electrical properties of colloids – Tyndall effect & applications - Ultra microscope, Electrical double layer and zeta potential - Coagulation of colloids, Hardy-Schulz rule, Gold number, sedimentation and streaming potential	3
	21	Gels: Elastic and non-elastic gels, Imbibition and syneresis, Micelles and critical micelle concentration	1
	22	Application of colloids – Cottrell precipitator, purification of water and delta formation.	1
V	**PRACTICALS: PHYSICAL CHEMISTRY PRACTICALS**		**30**
		A minimum of 8 practical experiments (Minimum one each from A & B)	
	23	**A. Lowering of freezing point** 1. Determination of K_f of solid solvent using a solute of known molecular mass. (Solvent: Naphthalene, biphenyl) (Solute: Naphthalene, biphenyl, 1,4-dichlorobenzene, diphenylamine) 2. Determination of molecular mass of the solute using a solvent of known K_f. (Solvent: Naphthalene, biphenyl) (Solute: Naphthalene, biphenyl, 1,4-dichlorobenzene, diphenylamine)	8
	24	**B. Depression of transition temperature** 3. Determination of molal transition point depression constant (Kt) of salt hydrate using solute of known molecular mass. (Salt hydrates: sodium thiosulphate penta hydrate, hydrated sodium acetate) (solutes: Urea, Glucose). 4. Determination of molecular mass of the solute using a solvent of known molal transition point depression constant (Kt). (Salt hydrates: sodium thiosulphate penta hydrate, hydrated sodium acetate) (solutes: Urea, Glucose)	8
	25	**C. Surface tension:** 5. Determination of Surface tension of any three liquids 6. Surface tension of binary mixtures and determination of concentration of an unknown mixture	4

	26	**D. Viscosity:** 7. Determination of viscosity of any three liquids 8. Viscosity of binary mixtures and determination of concentration of an unknown mixture	4
	27	**E. Refractive index experiments:** 9. Determination of refractive indices of any three liquids 10. Refractive indices of KCl solutions of different concentrations and determination of concentration of unknown KCl solution	4
	28	**F. Solid state:** 11. Indexing powder XRD patterns and determination of unit cell parameters of simple and/or bcc and/or fcc systems (Instructors must provide the powder XRD patterns and ask students to index it and calculate unit cell parameters)	

References:

Textbooks

1. P W Atkins, "*Physical Chemistry*", Oxford University Press
2. R L Madan, *Physical Chemistry*, Mc Graw Hill
3. Glasstone and Lewis, *Elements of Physical Chemistry*, Macmillan
4. Puri, Sharma & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co
5. P. C. Rakhit, *Physical Chemistry*, Sarat Book House, Calcutta
6. J. B. Yadav *Advanced Practical Physical Chemistry*, Krishna Prakashan Media (P) Ltd

For Further Reading

1. R J Selby and RA Alberty, *Physical Chemistry*, John Wiley &sons
2. Levin, *Physical Chemistry*, 5th edn, TMH.
3. Gurdeep Raj, *Advanced Physical Chemistry*, Goel publishing house
4. G W Castellan, "*Physical Chemistry*", Narosa Publishing House
5. B. Viswanathan, P. S. Raghavan, *A Practical Physical Chemistry*, Viva Books.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain a clear understanding of the structure and behaviour of solids to equip for its applications in materials science, electronics, and engineering.	R, U, Ap	PSO -1,2,3
CO-2	Possess a comprehensive understanding of the physical properties of liquids and liquid crystals	R, U	PSO -1,2,3
CO-3	Gain insight into the behaviour and applications of liquid crystals, leading to their utilization in various	U, Ap, An	PSO - 1,2,3,4

	technologies such as displays, sensors, and optical devices.		
CO-4	Understand the behaviour of gases, ranging from the ideal gas equation to the complexities of real gases	R, U	PSO -1,2,3
CO-5	Gain the idea of the principles governing dilute solutions, including concentration units such as molarity, molality, normality, and mole fraction and apply in analytical measurements.	U, Ap	PSO -1,2,3
CO-6	Gain insights into phenomena like coagulation, gels, and micelles, to address complex challenges in related fields.	U, Ap	PSO - 1,2,3,4
CO-7	Hands-on experience in conducting experiments related to the physical properties of solutions and solids	U, Ap, An	PSO - 1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHYSICAL CHEMISTY I

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO -1,2,3	R, U, Ap	F, C	L	-
2	CO-2	PO-1,6 PSO -1,2,3	R, U	F, C	L	-
3	CO-3	PO-1,6 PSO -1,2,3,4	U, Ap, An	F, C, M	L	-
4	CO-4	PO-1,6 PSO -1,2,3	R, U	F, C	L	-
5	CO-5	PO-1,6 PSO -1,2,3	U, Ap	F, C, M	L	-
6	CO-6	PO-1,6 PSO -1,2,3,4	U, Ap	F, C, M	L	-
7	CO-7	PO-1,2,6 PSO -1,2,3,5	U, Ap, An	F, C, P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	-	-	1	-	-	-	-	2	-	-
CO 2	3	3	3	-	-	1	-	-	-	-	2	-	-
CO 3	3	2	3	2	-	1	-	-	-	-	2	-	-
CO 4	3	3	3	-	-	1	-	-	-	-	2	-	-
CO 5	3	2	2	-	-	1	-	-	-	-	2	-	-
CO 6	3	2	2	2	-	1	-	-	-	-	2	-	-
CO 7	1	2	3	-	2	1	2	-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓	✓		✓
CO 7	✓			✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSCCHE201**				
Course Title	**ESSENTIALS OF PHYSICAL CHEMISTRY**				
Type of Course	**DSC**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge 2. First & second semester DSCs (chemistry) offered by UoK (preferable) 3. Basic knowledge in mathematics.				
Course Summary	The course gives students a thorough understanding of the fundamentals of physical chemistry and how they are applied in real-world situations. Topics covered include chemical and ionic equilibrium, electrochemistry, crystalline states, dilute solutions, and binary liquid systems. Students have practical experience in conducting physical chemistry experiments and analyzing experimental data through practical activities that help them build important laboratory skills.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		ESSENTIALS OF PHYSICAL CHEMISTRY	**75**
I	**CHEMICAL AND IONIC EQUILIBRIUM**		**9**
	1	Reversible reactions – K_P, K_C, and K_X and inter relationships – Free energy change and chemical equilibrium (thermodynamic derivation)	2
	2	Influence of pressure and temperature on the following reactions. (i) $N_2 + 3H_2 \rightarrow 2NH_3$ (ii) $PCl_5 \rightarrow PCl_3 + Cl_2$ (iii) $2SO_2 + O_2 \rightarrow 2SO_3$ Le Chatelier's principle and the discussion of the above reactions on its basis.	2
	3	Concepts of Acids and Bases, Arrhenius, Lowry-Bronsted, and Lewis concepts. HSAB Principle. Levelling effect.	1
	4	pH and its determination by potentiometric method. Buffer solutions – Henderson equation, Acidic and basic buffers-examples.	2
	5	Hydrolysis of salts – degree of hydrolysis and hydrolytic constant, Derivation of relation between Kw and Kh for salts of strong acid – weak base, weak acid - strong base and weak acid – weak base.	2
II	**ELECTRO CHEMISTRY**		**9**

	6	Application of conductance measurements. Conductometric titrations involving strong acid – strong base, strong acid – weak base, weak acid – strong base and weak acid – weak base.	2
	7	EMF – Galvanic cells, measurement of emf, cell and electrode potential, IUPAC sign convention, Reference electrodes, SHE and calomel electrode, standard electrode potential,	2
	8	Nernst equation, anion and cation reversible electrodes, redox electrode with examples, quinhydrone electrode, glass electrode	3
	9	Concentration cell without transference, potentiometric titration, Fuel cells – H_2 – O_2 and hydrocarbon – O_2 type.	2
III	**CATALYSIS AND PHOTO CHEMISTRY**		**9**
	10	General Characteristics of catalytic reactions. Different types of catalysis – examples	2
	11	Theories of catalysis (Outline of intermediate compound formation theory and adsorption theory).	2
	12	Enzyme catalysis – Michaelis-Menten mechanism.	2
	13	Photo Chemistry: - Laws of Photo Chemistry, Grothus – Drapter law, Beer Lambert's law, Einstein's laws, quantum yield, H_2 – Cl_2 reaction, H_2 – Br_2 reaction	2
	14	Fluorescence and phosphorescence, chemiluminescence and photo sensitization	1
IV	**DILUTE SOLUTIONS AND BINARY LIQUID SYSTEMS**		**18**
	15	Molarity, molality, Normality and mole fraction Colligative property – relative lowering of vapour pressure – elevation in boiling point – depression in freezing point – osmotic pressure – experimental determination of osmotic pressure – Isotonic solution – reverse osmosis	5
	16	Abnormal molecular mass - van't Hoff factor. (Numerical Problems to be worked out)	4
	17	Completely miscible liquid pairs, vapour pressure - composition curve, boiling point composition curve	3
	18	Ideal and non- ideal solutions, fractional distillations, azeotropes	3
	19	Partially miscible liquids - CST, phenol- water, nicotine-water system- Effect of impurities on miscibility and CST, Immiscible liquid pairs.	3
V	**PRACTICALS: PHYSICAL CHEMISTRY EXPERIMENTS**		**30**
		A minimum of 5 practical experiments out of which at least one each from sections I, II and III must be performed and reported.	
	20	**I. Conductometry**	5
		1. Determination of cell constant 2. Conductometric titration of NaOH using HCl	
	21	**II. Potentiometry**	6
		3. Potentiometric titration of Fe^{2+} versus $Cr_2O_7^{2-}$ 4. Potentiometric titration of KMnO4 versus KI	
	22	**III. Experiments with Partially miscible liquid pairs**	3
		5. Critical solution temperature of phenol –water system	

		6. Influence of KCl (impurity) on the miscibility temperature of Phenol-water system. Determination of concentration of given KCl solution	
	23	**IV. Adosrption Experiments**	6
		7. Freundlich and Langmuir isotherms for adsorption of oxalic acid on active charcoal. 8. Determination of unknown concentration of oxalic acid using isotherm.	
	24	**V. Calorimetry**	5
		9. Determination of water equivalent of Calorimeter and heat of neutralization of strong acid and strong base	
	25	**VI. Partition experiments**	5
		10. Partition coefficient of iodine between CCl_4 and H_2O or Partition coefficient of ammonia between $CHCl_3$ and H_2O	

References

1. P L Soni, O P Dharmarsha, U N Dash, *Textbook of Physical Chemistry*, 23rd Edn, Sultan Chand & Sons, New Delhi, 2011.
2. Gurudeep Raj, *Advanced physical chemistry*
3. F Daniel and R A Albert, *Physical chemistry*
4. N.M. Kapoor, *Physical Chemistry.*
5. J. B. Yadav *Advanced Practical Physical Chemistry*, Krishna Prakashan Media (P) Ltd

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Illustrate Le Chatelier's principle and predict the effect of pressure and temperature on reactions	Ap	PSO-1,2,3
CO-2	Categorise the nature of different salt solutions in daily life and calculate the pH	Ap	PSO-1,2,3
CO3	Construct electrochemical cells with different electrodes	Ap	PSO-1,2,3
CO 4	Calculate the strength of different solutions using conductometric / Potentiometric method.	Ap	PSO-1,2,3
CO 5	Identify the different crystals and draw their structures	An	PSO-1,2,3
CO 6	Understand different colligative properties and calculate molecular mass of solute	Ap	PSO-1,2,3

CO 7	Explain CST of liquid pairs and identify the effect of electrolyte on it	E	PSO-1,2,3
CO 8	Apply the principles in physical chemistry experiments	Ap	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ESSENTIALS OF PHYSICAL CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO1	PO-1,6 PSO-1,2,3	Ap	F, C, M	L	-
2	CO2	PO-1,6 PSO-1,2,3	Ap	F, C, M	L	-
3	CO3	PO-1,6 PSO-1,2,3	Ap	F, C, M	L	-
4	CO4	PO-1,6 PSO-1,2,3	Ap	F, C, M	L	-
5	CO5	PO-1,6 PSO-1,2,3	An	F, C, M	L	-
6	CO6	PO-1,6 PSO-1,2,3	Ap	F, C, M	L	-
7	CO7	PO-1,6 PSO-1,2,3	E	F, C, M	L	-
8	CO8	PO-1,2,6 PSO-1,2,3,4,5	Ap	F, C, P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	1	-	-	-	-	2	-	-

CO 2	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 3	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 4	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 5	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 6	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 7	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 8	2	2	2	2	2	1	2	-	-	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓
CO 7	✓	✓		✓
CO 8	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSCCHE202**				
Course Title	**CHEMICAL INSIGHTS: FROM SOIL TO PETROCHEMICALS**				
Type of Course	**DSC**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	4. Higher secondary level science knowledge 5. First & second semester DSCs (chemistry) offered by UoK (preferable)				
Course Summary	This course covers soil and water chemistry, electrochemistry, petrochemicals, instrumental methods of analysis, and practical physical chemistry experiments. Students gain insights into the chemical processes governing soil and water behaviour, industrial applications of electrochemistry and petrochemicals, and hands-on experience in various analytical techniques.				

Detailed Syllabus:

Module	Unit	Content	Hrs
	CHEMICAL INSIGHTS: FROM SOIL TO PETROCHEMICALS		**75**
I	**SOIL AND WATER CHEMISTRY**		**18**
	1	Soil – Composition, mineral matter in soil process of soil formation, weathering – physical (mention), chemical (detail) + biological (mention) Saline and alkaline soil (brief explanation) Rocks – different types (Igneous, sedimentary and Metamorphic)	5
	2	Analysis of lime stone (qualitative treatment only)	1
	3	Chemistry of salt-affected soils and amendments, soil pH, ECe, ESP, SAR and important relation	3
	4	Soil management and amendments. Chemistry and electrochemistry of submerged soils	2
	5	Water Analysis Water quality parameters COD, BOD, main quality characteristics of water (alkalinity, hardness, total solids and oxidation)	3
	6	Water treatment including chemical (Precipitation, aeration, osonisation, chlorination) and physical methods of sterilization.	4
II	**ELECTRO CHEMISTRY**		**9**

	7	Transport number – definition, determination by Hittorffs method and moving boundary method, application of conductance measurements	2
	8	Conductometric titrations involving strong acid – strong base, strong acid – weak base, weak acid – strong base and weak acid – weak base	2
	9	EMF – Galvanic cells, measurement of emf, cell and electrode potential, IUPAC sign convention, Reference electrodes, SHE and calomel electrode	1
	10	Standard electrode potential, Nernst equation, anion and cation reversible electrodes, redox electrode with examples, quinhydrone electrode, glass electrode	2
	11	Concentration cell without transference, Potentiometric titration Fuel cells – H_2 – O_2 and hydrocarbon – O_2 type	2
III	**PETRO CHEMICALS**		**9**
	12	Introduction to crude oil, exploratory methods, constitution of crude oil, natural gas – constituents	2
	13	Distillation of crude oil, separation of natural gas and different fractions Meaning of terms such as ignition point, flash point, octane number	2
	14	Types of hydrocarbon fuels and their characteristics	2
	15	Cracking – catalytic cracking, hydro cracking, isomerization, reforming, sulphur, hydrogen, petroleum, coke and nitrogen compounds from petroleum	3
IV	**INSTRUMENTAL METHODS OF ANALYSIS**		**9**
	16	Spectral methods – Atomic Absorption Spectroscopy (AAS) principle, measurement, advantages, disadvantages, and applications	2
	17	Flame Emission Spectroscopy (FES) principle, measurement (single beam method) applications	2
	18	Thermal methods: Themogravimetric analysis (TG) principle and method, Factors affecting thermogravimetric analysis, Application	3
	19	Determination of Surface tension- capillary rise and stalagmometer method, Viscosity- Poiseuilles equation, Determination of viscosity- Ostwald's viscometer, Refractive index determination by Abbe refractometer	2
V	**PRACTICALS: PHYSICAL CHEMISTRY EXPERIMENTS**		**30**
		A minimum of 5 practical experiments out of which at least one each from sections I and II must be performed and reported.	
	20	**I. Conductometry**	8
	21	11. Determination of cell constant 12. Conductometric titration of NaOH using HCl	
	22	**II. Potentiometry**	8
		13. Potentiometric titration of Fe^{2+} versus $Cr_2O_7^{2-}$ 14. Potentiometric titration of KMnO4 versus KI	
	23	**III. Surface tension:** 15. Determination of Surface tension of any three liquids 16. Surface tension of binary mixtures and determination of concentration of an unknown mixture	8

		IV. Viscosity: 17. Determination of viscosity of any three liquids 18. Viscosity of binary mixtures and determination of concentration of an unknown mixture	
	24	**V. Refractive index experiments:** 19. Determination of refractive indices of any three liquids 20. Refractive indices of KCl solutions of different concentrations and determination of concentration of unknown KCl solution	6

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2. Manas Chanda, *Atomic structure and Chemical bonding in molecular spectroscopy*, Tata Mc Graw Hill.
3. J D Lee, *Concise Inorganic Chemistry*, ELBS.
4. Miller T. G. Jr., *Environmental Science*, Wadsworth publishing House, Meerut Odum.E.P.1971.
5. Odum, E.P. (1971) *Fundamentals of Ecology*. Third Edition, W.B. Saunders Co., Philadelphia
6. S. E. Manahan, *Environmental chemistry*, 1993, Boca Raton, Lewis publisher
7. *Environmental chemistry*, Sharma and Kaur, 2016, Krishna publishers
8. Puri, Sharma, Pathania *Principles of Physical Chemistry*
9. B. K. Sharma, *Instrumental methods of Chemical Analysis*
10. D.A Skoog, D M West, F J, Holler, S R Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brookes/Cole, Thomson Learning, Inc, USA, 2004
11. B. K. Sharma, *Soil and Noise pollution.*

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the chemicals affecting soils	U	PSO-1,2,3,4,5
CO-2	Get an insight in to petro chemical industry	U	PSO-1,2,3,4,5
CO3	Identify the water quality parameters.	Ap	PSO-1,2,3,4,5
CO 4	Couple different electrode and construct electrochemical cells	Ap	PSO-1,2,3,5
CO 5	Appreciate the use of sophisticated instruments	Ap	PSO-2,3,4,5
CO 6	Apply the basic principles in Physical chemistry experiments	Ap	PSO-1,2,3,4,5
CO 7	Identify the characteristics of given soil and water samples	E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMICAL INSIGHTS: FROM SOIL TO PETROCHEMICALS

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO- 1,6 PSO-1,2,3,4,5	U	F, C	L	-
2	CO-2	PO- 1,6 PSO-1,2,3,4,5	U	F, C	L	-
3	CO3	PO- 1,6 PSO-1,2,3,4,5	Ap	F, C	L	-
4	CO 4	PO- 1,2,3,6,7 PSO-1,2,3,5	Ap	F, C, P	L	-
5	CO 5	PO- 1,2,3,6,7 PSO-2,3,4,5	Ap	F, C, P	-	P
6	CO 6	PO- 1,6 PSO-1,2,3,4,5	Ap	C, P	-	P
7	CO 7	PO- 1,2,3,6,7 PSO-1,2,3,4,5	E	C, P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of Cos with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	3	3	1	-	-	-	-	2	-	-
CO 2	3	3	3	3	3	1	-	-	-	-	2	-	-
CO 3	3	3	3	3	3	1	-	-	-	-	2	-	-
CO 4	3	3	2	-	2	1	2	2	-	-	2	2	-
CO 5	-	2	3	2	2	1	2	2	-	-	2	2	-
CO 6	3	2	2	1	2	1	-	-	-	-	2	-	-
CO 7	1	3	3	3	2	1	2	2	-	-	2	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of Cos to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓
CO 6	✓		✓	✓
CO 7	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSCCHE203**				
Course Title	**NATURAL PRODUCT CHEMISTRY**				
Type of Course	**DSC**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	6. Higher secondary level science knowledge 7. First & second semester DSCs (chemistry) offered by UoK (preferable)				
Course Summary	The course covers chromatography principles and applications, biochemistry of amino acids, proteins, and nucleic acids, analysis of oils, fats, alkaloids, vitamins, and terpenes, carbohydrate and natural polymer chemistry, and practical organic preparations and analytical techniques. Students gain comprehensive knowledge and practical skills in organic chemistry, biochemistry and analytical chemistry.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		NATURAL PRODUCT CHEMISTRY	**75**
I	**BIOINORGANIC CHEMISTRY**		**9**
	1	Metalloporphyrins – cytochromes – Chlorophyll - photosynthesis and respiration	3
	2	Haemoglobin and myoglobin, mechanism of O_2 – CO_2 transportation	2
	3	Nitrogen fixation, carbon fixation and carbon cycle	2
	4	Biochemistry of iron toxicity and nutrition, essential and trace elements in biological systems	2
II	**AMINO ACIDS, PROTEINS & NUCLEIC ACIDS**		**9**
	5	Classification and properties of amino acids, Synthesis of glycine, alanine and tryptophan	2
	6	Polypeptides and proteins, peptide linkage, peptide synthesis Primary, secondary, tertiary and quaternary structure of proteins, Test for proteins	3
	7	Enzymes – Characteristics, catalytic action, theory of enzyme catalysis – Michaelis – Menton theory- Co-enzymes	2

	8	RNA, DNA – their biological role, hydrolysis of nucleoproteins, elementary idea regarding the structure of nucleic acids Replication of DNA- Transcription and Translation - Genetic code	2
III	**OILS, FATS, ALKALOIDS, VITAMINS AND TERPENES**		**9**
	9	Oils and Fats: Occurrence and extraction-Analysis of oils and fats saponification value, iodine value and acid value	2
	10	Alkaloids: - Extraction and structural elucidation of conine and importance of quinine, morphine and codeine	3
	11	Terpenes: Classification- Isoprene and special isoprene rule-Isolation of essential oils citral and geraniol (No structural elucidation)	2
	12	Vitamins: - Classification and structure, functions and deficiency diseases (structures of vitamin A, B1 and C but no structural elucidation	2
IV	**CARBOHYDRATES AND NATURAL POLYMERS**		**18**
	13	Classification. Configuration- glyceraldehyde, erythrose, threose, ribose, 2-deoxy ribose, arabinose, glucose, fructose and mannose	3
	14	Preparation and properties of glucose and fructose	3
	15	Pyranoside structures of glucose and fructose, furanoside structure of fructose (structure elucidation not expected) Mutarotation and epimerization Properties and structure of sucrose. (structure elucidation not expected)	4
	16	Structure of starch and cellulose (Elementary idea only)	2
	17	Natural rubber – Isolation, vulcanisation - characteristics and applications	3
	18	Synthesis and applications of biodegradable polymers – PLA, PGA, PHBV, PHB, Nylon – 2 –nylon - 6	4
V	**PRACTICALS – Organic Preparations, Dyes, Food analysis, Drug analysis, Fertilizer analysis**		**30**
	19	**Section A (Any 8 Experiments from Section A are compulsory)** Organic preparation: 1. Acetylation of salicylic acid or aniline 2. Benzoylation of phenol or aniline 3. Nitration of Acetanilide or nitrobenzene 4. Halogenation: Bromination of acetanilide 5. Oxidation of benzaldehyde/Toluene/Benzyl chloride 6. Hydrolysis of ethyl acetate and benzamide 7. Methyl orange 8. Picric acid 9. Phenyl urea 10. Methylene blue Purification of organic compounds Purity of organic compounds – MP and BP Recrystallisation of organic compounds Preparation of dyes Preparation of aspirin TLC of simple organic compounds- cresol, napthol, nitrobenzene	15

	20	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add experiments)** 1. Dichrometric titrations: 2. Iodimetry and Iodometry 3. Complexometric titrations: 4. Complexometric Titration: Determination of calcium content in milk. 5. Precipitation Titration: Determination of salt content in potato chips 6. Estimation of saponification value of fats/oils. 7. Determination of hardness of water. 8. Determination of available chlorine in bleaching powder. 9. Redox Titration: Determination of Vitamin C Content in Tablets. 10. Complexometric Titration: Determination of Magnesium Content in Antacids. 11. Precipitation Titration: Determination of Chloride Content in Saline Solutions. 12. Redox Titration: Determination of Iron Content in Iron Supplements 13. Complexometric Titration: Determination of Zinc Content in Zinc Supplements. 14. pH meter: Determination of pH of Fertilizer Solution.	15

References

1. B. K. Sharma, *Instrumental methods of Chemical Analysis*.
2. D.A Skoog, D M West, F J, Holler, S R Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brookes/Cole, Thomson Learning, Inc, USA,2004
3. B. K. Sharma, *Industrial Chemistry*
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5. J. L. Jain, Sunjay Jain, Nitin Jain, *Fundamentals of Biochemistry*, S. Chand & Co. Ltd.
6. R K Murray, DK Granner, PA Mayers, VW Rodwell, *Harper's Biochemistry*, Prentiace- Hall International Editions.
7. I. L Finar, *Organic Chemistry – Vol. 1*
8. *Vogel's Textbook of Practical Organic Chemistry* Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R., 5th ed., Pearson Education.
9. *Practical Organic Chemistry*, Mann, F.G.; Saunders, B.C., 4th ed., Pearson Education.
10. *Comprehensive Practical Organic Chemistry – Preparation and Quantitative Analysis* Ahluwalia, V.K.; Aggarwal, R. Universities Press.
11. *Advanced Practical Organic Chemistry*, Vishnoi, N.K., 3rd ed., Vikas Publishing House, New Delhi, 2010.

Course Outcomes

No.	Upon completion of the course the graduate will be	Cognitive	PSO

	able to	Level	addressed
CO-1	Discuss the principle and applications of chromatography and electrophoresis	U	PSO-1,2,3
CO-2	Classify amino acids, proteins, carbohydrates and vitamins. Identify and distinguish the structure of amino acids, peptides, proteins and nucleic acids	Ap	PSO-1,2,3
CO 3	Discuss the extraction process and general properties of natural products -oils, fats, terpenes and alkaloids	U	PSO-1,2,3
CO 4	Apply the basic principles in Organic chemistry experiments	Ap	PSO-1,2,3
CO 5	Prepare medicinal compounds	E	PSO-1,2,3,4
CO 6	Identify the principles in analytical chemistry for prepare and purify organic compounds.	Ap	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: NATURAL PRODUCT CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	Ap	F, C	L	-
3	CO 3	PO-1,6 PSO-1,2,3	U	F, C	L	-
4	CO 4	PO-1,2,6 PSO-1,2,3	Ap	C, P	-	P
5	CO 5	PO-1,2,3,6 PSO-1,2,3,4	E	C, P	-	P
6	CO 6	PO-1,2,3,6 PSO-1,2,3,4,5	Ap	C, P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	-	-	1	-	-	-	-	2	-	-
CO 2	3	3	3	-	-	1	-	-	-	-	2	-	-
CO 3	3	3	3	-	-	1	-	-	-	-	2	-	-
CO 4	3	3	3	-	-	1	1	-	-	-	3	-	-
CO 5	2	3	3	2	-	1	1	1	-	-	3	-	-
CO 6	2	3	3	2	3	1	1	2	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSCCHE204**				
Course Title	**CHEMISTRY UNVEILED: EVERYDAY APPLICATIONS**				
Type of Course	**DSC**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	8. Higher secondary level science knowledge 9. First & second semester DSCs (chemistry) offered by UoK (preferable)				
Course Summary	The course covers textile chemistry, food chemistry, chemistry and agriculture, basics of perfumery, cosmetics, paper manufacturing, and drug classification. Practical sessions encompass dyes, food analysis, drug analysis, and fertilizer analysis, offering hands-on experience.				

Detailed Syllabus:

Module	Unit	Content CHEMISTRY UNVEILED: EVERYDAY APPLICATIONS	Hrs 75
I	**TEXTILE CHEMISTRY**		**9**
	1	Definition, Requisite of a true dye, Types of fibres: structure features of fibres (Cotton, wool, silk, cellulose acetate, polyamide, polyesters)	3
	2	Basic operations in dyeing process (preparation of the fibre, preparation of dye bath, application of dye and finishing), Various methods of dyeing (direct dyeing, vat dyeing, Mordant Dyeing, and disperse dyeing).	3
	3	Witt's theory of colour and constitution, classification of dyes based on their functional group- i) Nitro ii) Nitroso and iii) Azo, Pollution problem due to dye industry.	3
II	**FOOD CHEMISTRY**		**9**
	4	Food additives – definition. Preservatives (examples), Food colours - permitted and non-permitted (examples), Toxicology. Flavours - natural and synthetic (examples),	3
	5	Artificial sweeteners (examples), Emulsifying agents (examples), Antioxidants (examples), Leavening agents (examples) and Flavour enhancers (examples). Importance of food additives.	3
	6	Soft drinks - formulation and health effects. Health drinks.	1
	7	Fast foods and junk foods and their health effects. Food adulteration (with examples). Food laws and standards. Food Safety and Standards Act, 2006.	2

III	**CHEMISTRY AND AGRICULTURE**		**9**
	8	Fertilizers – Introduction. Types of fertilizers - Natural, synthetic, mixed, NPK fertilizers (examples). Excessive use of fertilizers and its impact on the environment. Bio-fertilizers. Plant growth hormones.	4
	9	Pesticides - Introduction. Classification - Insecticides, Fungicides, Herbicides.	3
	10	Excessive use of pesticides - Environmental hazards. Bio pesticides.	2
IV	**PERFUMERIES, COSMETICS, PAPERS, & DRUGS**		**18**
	11	Perfumes: Definition and history of perfumery - Importance of perfumes in society and culture, Classification of fragrance ingredients (natural vs. synthetic – with examples), Chemical structure and properties of key fragrance compounds (terpenes, aldehydes, ketones, esters, etc. with examples) Relationship between chemical structure and fragrance.	5
	12	Cosmetics - Introduction. General formulation of different types of cosmetics – Dental cosmetics, Shampoos, Hair dyes, Skin products (creams and lotions, lipstick, perfumes, deodorants and antiperspirants), Bath oil, Shaving cream and Talcum powder. Toxicology of cosmetics.	5
	13	Paper – Introduction. Paper manufacture (basic idea only). Weight and size of paper. Types of paper - News print paper, writing paper, paperboards, cardboards. Environmental impact of paper. International recycling codes, and symbols for identification of paper, plastic and metals. Natural and synthetic dyes in paper industry with examples (elementary idea only).	5
	14	Classification of drugs - Analgesics, Antipyretics, Antihistamines, Antacids, Antibiotics and Antifertility drugs with examples. Psychotropic drugs - Tranquilizers, Antidepressants and Stimulants with examples. Drug addiction and abuse. Prevention and treatment.	3
V	**PRACTICALS – Organic Preparations, Dyes, Food analysis, Drug analysis, Fertilizer analysis**		**30**
	1.	**Section A (Any 5 Experiments from Section A are compulsory)** Organic preparation: 11. Acetylation of salicylic acid or aniline 12. Benzoylation of phenol or aniline 13. Nitration of Acetanilide or nitrobenzene 14. Halogenation: Bromination of acetanilide 15. Oxidation of benzaldehyde/Toluene/Benzyl chloride 16. Hydrolysis of ethyl acetate and benzamide 17. Methyl orange 18. Picric acid 19. Phenyl urea 20. Methylene blue	15
	2.	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add experiments)**	15

		15. Dichrometric titrations: 16. Iodimetry and Iodometry 17. Complexometric titrations: 18. Complexometric Titration: Determination of calcium content in milk. 19. Precipitation Titration: Determination of salt content in potato chips 20. Estimation of saponification value of fats/oils. 21. Determination of hardness of water. 22. Determination of available chlorine in bleaching powder. 23. Redox Titration: Determination of Vitamin C Content in Tablets. 24. Complexometric Titration: Determination of Magnesium Content in Antacids. 25. Precipitation Titration: Determination of Chloride Content in Saline Solutions. 26. Redox Titration: Determination of Iron Content in Iron Supplements 27. Complexometric Titration: Determination of Zinc Content in Zinc Supplements. 28. pH meter: Determination of pH of Fertilizer Solution.	

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1. *Text Book of Organic Chemistry*: B.S. Bahl and G.D. Tuli, S. Chand Publication, New Delhi.
2. *A Text Book of Engineering Chemistry*, S.S. Dara and Suresh Umare, S. Chand Publication, New Delhi.
3. *A Text Book of Basic and Applied Chemistry*, P.C. Jain and Monica Jain.
4. *Text Book of Organic Chemistry* by J. L. Finar, Longman Publication.
5. *Synthetic Dyes* by G R Chatwal, Himalaya Publishing House, New Delhi.
6. *Organic Chemistry of Natural Products* Vol. I and II, by G. R. Chatwal, Himalaya Publishing House, New Delhi.
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8. *Soil Fertility and Fertilizers,* S.L. Tisdale; W. L. Nelson and J. D. Beaton, Macmillan Publishing Company, New York, 1990.
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14. *Synthetic Drug* by G R Chatwal and Anand, Himalaya Publishing House, New Delhi.
15. *Vogel's Textbook of Practical Organic Chemistry* Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R., 5th ed., Pearson Education.
16. *Practical Organic Chemistry,* Mann, F.G.; Saunders, B.C., 4th ed., Pearson Education.

17. *Comprehensive Practical Organic Chemistry – Preparation and Quantitative Analysis* Ahluwalia, V.K.; Aggarwal, R. Universities Press.
18. *Advanced Practical Organic Chemistry*, Vishnoi, N.K., 3rd ed., Vikas Publishing House, New Delhi, 2010.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of textile chemistry, enabling to analyze and implement dyeing processes effectively while considering environmental impacts.	R, U, Ap	PSO-1,2,3,4
CO-2	Possess an understanding of food additives and their impact on food quality, safety, and consumer health, preparing for careers in food science, nutrition, and regulatory affairs.	U, Ap	PSO-1,2,3,4
CO-3	Equip with the knowledge to analyze and address the use of fertilizer and pesticide use in agriculture, with a focus on promoting sustainable and environmentally-friendly practices.	U, Ap	PSO-1,2,3,4
CO-4	Understand the chemistry of perfumery and cosmetics, preparing them for careers in the fragrance industry and cosmetic formulation.	U, Ap, An	PSO-1,2,3,4
CO-5	Acquire knowledge of paper manufacturing processes and its environmental considerations and prepare for careers in the paper industry and pharmaceuticals.	U, Ap, An	PSO-1,2,3,4,5
CO-6	Enhance the problem-solving abilities, critical thinking skills, and proficiency in laboratory procedures,	An, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY UNVEILED: EVERYDAY APPLICATIONS

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,3,6	R, U, Ap	F, C, P	L	-

		PSO-1,2,3,4				
2	CO-2	PO-1,3,6 PSO-1,2,3,4	U, Ap	C, P, M	L	-
3	CO-3	PO-1,3,6 PSO-1,2,3,4	U, Ap	C, P, M	L	-
4	CO-4	PO-1,3,6 PSO-1,2,3,4	U, Ap, An	C, P, M	L	-
5	CO-5	PO-1,3,6,8 PSO-1,2,3,4,5	U, Ap, An	P, M	L	-
6	CO-6	PO-1,3,6 PSO-1,2,3,4,5	An, E	P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	2	-	2	-	2	-	-	2	-	-
CO 2	3	3	3	2	-	2	-	2	-	-	2	-	-
CO 3	3	3	3	2	-	2	-	2	-	-	2	-	-
CO 4	3	3	3	2	-	2	-	2	-	-	2	-	-
CO 5	3	3	3	2	2	2	-	2	-	-	2	-	-
CO 6	2	2	3	2	3	2	-	3	-	-	3	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSCCHE205**				
Course Title	**BIOMOLECULES AND BIOPHYSICAL CHEMISTRY-II**				
Type of Course	**DSC**				
Semester	3				
Academic Level	200 – 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higher secondary level science knowledge 2. First & second semester DSCs (chemistry) offered by UoK (preferable)				
Course Summary	This course includes topics of enzymes, lipids, kinetics of reactions, metabolism of compounds and bioenergetics. Students can learn about enzymes, classification of enzymes, importance of enzymes and their role in life. This course also discusses the chemistry of lipids and kinetics of reactions. Students learnt about metabolism of various compounds, and fundamentals of bioenergetics.				

Detailed Syllabus:

Module	Unit	Content BIOMOLECULES AND BIOPHYSICAL CHEMISTRY-II	Hrs 75
1	**INTRODUCTION TO ENZYMES & LIPIDS**		**18**
	1	Enzymes – Chemical nature and Features of active site. Enzyme Specificity – Stereo, reaction, substrate and broad specificity. Enzyme Commission system of classification and nomenclature of enzymes: six major classes of enzymes with one example each.	3
	2	Coenzymes and their functions - NAD, NADP+, FAD, FMN, lipoic acid, pyridoxal phosphate, biotin and cyanocobalamin. Ribozymes, Measurement and expression of enzyme activity, Definition of IU, katals, enzyme turnover number.	3
	3	Isoenzymes- Lactate dehydrogenase Applications of enzymes – Enzymes as therapeutic agents, as analytical reagents, immobilized enzymes	3
	4	Lipids: Definition, basic ideas about the biochemical functions of lipids. Classification of lipids with examples, classification of fatty acids, physical and chemical properties of fatty acids.	2

	5	Structure of the following fatty acids- stearic acid, oleic acid, linoleic acid, arachidonic acid. Structure of triacylglycerol.	2
	6	Saponification number, acid number and iodine number of fats. Essential and non-essential fatty acids with examples	2
	7	Compound lipids: membrane lipids- Structure and functions of phospholipids- phosphatidic acid, lecithin, cephalin, and phosphatidyl serine, Functions of Sphingolipids.	2
	8	Steroids: Strucutre and functions of cholesterol and ergosterol	1
II	**CHEMICAL KINETICS**		**9**
	9	Rate of reactions, various factors influencing rate, order, molecularity, zero, first, second, third order reactions. Rate determining step. Derivation of first order kinetics - fractional life time, units of rate constants	3
	10	Influence of temperature on reaction rates, Arrhenius equation, Calculation of Arrhenius parameters.	2
	11	Factors affecting enzyme catalysed reactions - effect of substrate concentration, enzyme concentration, temperature, pH and activators. Mechanism of Enzyme action - Activation energy, Interaction between enzyme and substrate- lock and key model, induced fit model. Enzyme kinetics - Km and its significance, Michaelis Menton equation (without derivation), Lineweaver- Burk plot. Significance of Km and Vm values.	4
III	**INTRODUCTION TO METABOLISM**		**9**
	11	Metabolism- catabolism and anabolism Metabolism of carbohydrates – Glycolysis and citric acid cycle, Electron transport chain and Oxidative phosphorylation.	3
	12	Glycogenesis and glycogenolysis, Gluconeogenesis (Mention only) .	1
	13	Metabolism of lipids - Metabolism of triglycerides, Outline study of β-oxidation of saturated and unsaturated fatty acids	3
	14	Metabolism of amino acids – Proteolysis, Urea cycle.	2
IV	**BIOENERGETICS**		**9**
	15	Basic concepts – System – surroundings – open, closed and isolated systems – Isothermal– isochoric and isobaric process.	3
	16	Biochemical thermodynamics, first and second law of thermodynamics, Enthalpy, Entropy and Free energy. Criteria for reversible and irreversible process - Gibbs free energy equation.	3
	17	Relationship between standard free energy change and equilibrium constant. Standard free energy changes at pH 7.0 ($\Delta G'$), additive nature of $\Delta G'$, ATP as universal currency of free energy in biological systems. Photosynthesis – solar energy harvesting	3
V	**PRACTICAL- Physical chemistry experiments & Organic experiments**		**30**
	18	**Section A: Organic Quantitative Analysis: 4 Experiments from Section A are compulsory** 1. Saponification number of fats 2. Acid number of fats	15

		3. Iodine number of fats 4. Separation of photosynthetic pigments by TLC 5. Estimation of total chlorophyll, chlorophyll a and chlorophyll b pigments from the leaves.	
	19	**Section B (Open ended: Any 3 experiments are to be conducted - May be selected from the list or the teacher can add experiments)** 1. Kinetics a. Determination of rate constant of hydrolysis of methyl acetate b. Determination of rate constant of saponification of ethyl acetate. c. Kinetics of dye degradation using spectrophotometer 2. Preparation of acidic and basic buffer 3. Measurement of pH of buffers using pH meter 4. Heat of neutralisation of strong acid – strong base titration.	15

References:

1. Dr. U. Satyanarayana, Dr. U. Chakrapani, *Biochemistry*, Books and Allied (P) Ltd
2. J. L. Jain, Sunjay Jain, Nitin Jain, *Fundamentals of Biochemistry*, S. Chand & Co. Ltd.
3. RK Murray, DK Granner, PA Mayers, VW Rodwell, *Harper's Biochemistry*, Prentiace-Hall International Editions.
4. Sharma, Madan and Pahania, *Principles of Physical Chemistry*, Vishal Publishing Co.
5. J.D. Lee, *Concise Inorganic Chemistry*.
6. Puri, Sharma and Kalia, *"Inorganic Chemistry"*.
7. Arthur I. Vogel, B. S. Furniss, *Vogel's Textbook of practical organic chemistry*, 5th ed., Longman Scientific & Technical, London, 1996.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the classification of enzymes and their biological importance	U	PSO-1,2,3
CO-2	Explain the classification of lipids, their structure and biological importance	U	PSO-1,2,3
CO3	Explain the basic concepts of kinetics of chemical reactions	U	PSO-1,2,3
CO 4	Outline the metabolism of carbohydrates, fatty acids and proteins	U	PSO-1,2,3

CO 5	Explain the basic concepts of thermodynamics and relevance of themodynamics in biological processes.	U	PSO-1,2,3
CO 6	proficiency in conducting and analyzing quantitative experiments, thereby enhancing practical skills	U, Ap	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: BIOMOLECULES AND BIOPHYSICAL CHEMISTRY-II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	U	F, C	L	-
3	CO3	PO-1,6 PSO-1,2,3	U	F, C	L	-
4	CO 4	PO-1,6 PSO-1,2,3	U	F, C	L	-
5	CO 5	PO-1,6 PSO-1,2,3	U	F, C	-	P
6	CO 6	PO-1,2,6 PSO-1,2,3,4				

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 2	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 3	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 4	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 5	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 6	1	3	2	2	-	1	2	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK3DSCCHE206</td></tr>
<tr><td>Course Title</td><td colspan="5">GENERAL CHEMISTRY III</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">3</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">3. Higher secondary level science knowledge
4. First & second semester DSCs (chemistry) offered by UoK (preferable)</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course delves into the chemistry behind drugs, food additives, energy production and storage, fertilizers, explosives, and polymers. Through theoretical exploration and practical experiments, students will gain a comprehensive understanding of the synthesis, properties, and applications of these substances, contributing to fields such as medicine, agriculture, energy, and materials science. The course emphasizes the interdisciplinary nature of chemistry and its significance in addressing societal needs and challenges related to health, food safety, energy, and environmental sustainability.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content GENERAL CHEMISTRY III	Hrs 75
I		**CHEMISTRY OF DRUGS & FOOD ADDITIVES**	**18**
	1	Classification of drugs- analgesic, antipyretic, antibiotic, hypnotics, sulpha drugs, antacids, antimalarials with examples – Mode of action of sulpha drugs	6
	2	Structure of aspirin, sulphaguanidine, Paracetamol Drugs of plant origin-anticancer compounds from plants (elementary idea only)	3
	3	Food additives – definition. Preservatives (examples), Food colours - permitted and non-permitted (examples), Toxicology. Flavours - natural and synthetic (examples)	3
	4	Artificial sweeteners (examples), Emulsifying agents (examples), Antioxidants (examples), Leavening agents (examples) and Flavour enhancers (examples). Importance of food additives.	3

	5	Soft drinks - formulation and health effects. Health drinks. Fast foods and junk foods and their health effects. Food adulteration (with examples). Food laws and standards. Food Safety and Standards Act, 2006.	3
II	**CHEMISTRY FOR ENERGY PRODUCTION & STORAGE**		**9**
	6	Primary and secondary batteries, battery components and their role	2
	7	Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery.	4
	8	Fuel cells, Solar cell and polymer cell.	3
III	**FERTILIZERS & EXPLOSIVES**		**9**
	9	Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.	6
	10	Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.	3
IV	**POLYMERS**		**9**
	11	Introduction. Classification of polymers: Natural, synthetic; linear, cross-linked and network; plastics, elastomers, fibres; homopolymers and copolymers. Polymerization reactions.	3
	12	Typical examples: Polyethylene, polypropylene, PVC, phenol-formaldehyde and melamine formaldehyde resins, polyamides (nylons) and polyesters.	4
	13	Natural rubber: structure, latex processing methods, vulcanization and uses.	
	14	Synthetic rubbers: SBR, nitrile rubber and neoprene. Biodegradability of polymers, environmental hazards. Recycling of plastics.	2
V	**PRACTICALS**		
	15	**Section A:** **IX. REACTIONS OF THE FOLLOWING CATIONS:** Hg^{+}, Pb^{2+}, Ag^{+}, Hg^{2+}, Bi^{3+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}, Sn^{4+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Mn^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+} and NH_4^{+}. **X. SYSTEMATIC ANALYSIS OF TWO CATIONS IN A MIXTURE** The cations must be provided in solutions. A student must analyze **at least 5 mixtures** containing two cations each. **OR** **Section A: Organic Qualitative Analysis (Any 5 compounds with different functional groups are compulsory)** Systematic analysis with a view to identify the organic compound (aromatic – aliphatic, saturated – unsaturated, detection of elements and detection of functional groups) – polynuclear hydrocarbons, alcohols,	

		phenols, halogen compounds, nitro compounds, amino compounds, aldehydes, ketones, carboxylic acids, amides, urea, thiourea and esters. Only monofunctional compounds are to be given. **(Make sure that the practicals conducted for second minor students are different from that of first minor DSC)**	
	16	**Section B: OPEN ENDED PRACTICALS (Any 3 experiments)** 1. Test for the presence of food additives in common food items by spot tests or chromatography techniques and known food additives as reference standards. 2. Measurement of the acidity of soft drinks by pH indicator strips or a pH meter. 3. Investigation of the antioxidant properties of different food items calorimetrically using a known antioxidant (e.g., vitamin C) as standard. 4. Detection of common adulterants in food products such as starch in milk, synthetic colors in spices, or urea in edible oils. 5. Construction of simple galvanic cell. 6. Measurement of pH of solutions prepared from different fertilizers. **(May be selected from the list or the teacher can add experiments)**	15

References:

1. D. Sriram and P. Yogeeswari, *Medicinal Chemistry* 2nd edn. Pearson, 2011.
2. G R Chatwal and Anand, *Synthetic Drug* Himalaya Publishing House, New Delhi.
3. G. R. Chatwal, *Organic Chemistry of Natural Products* Vol. I and II, Himalaya Publishing House, New Delhi.
4. B. Sreelakshmi, *Food Science*, New Age International, New Delhi.
5. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
6. P. C. Jain & M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
7. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
8. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.
9. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
10. S.L. Tisdale; W. L. Nelson and J. D. Beaton, *Soil Fertility and Fertilizers*, Macmillan Publishing Company, New York, 1990.
11. K. H. Buchel, *Chemistry of Pesticides*, John Wiley & Sons, New York, 1983.
12. V.R. Gowarikar, N.V. Viswanathan, J. Sreedhar, *Polymer Science*, 2nd edn., New Age International Pvt. Ltd., 2015.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Understand of drug classification and mode of action, facilitating basic pharmacological knowledge.	U	PSO-1,2
CO-2	Facilitate the understanding of food additives, their functions, regulations, and health effects, enabling to make contributions to food industry with safety and quality assurance.	U, Ap	PSO-1,2,3,4
CO-3	Understanding of various types of batteries and energy storage devices, empowering to contribute to advancements in renewable energy technology and sustainable energy solutions.	U, Ap	PSO-1,2,3,4
CO-4	Gain knowledge on manufacturing processes, properties, and applications of fertilizers and explosives, for roles in related industries.	Ap, An	PSO-1,2,3,4
CO-5	Study polymer chemistry, including its biodegradability and recycling, preparing for careers in related with a focus on sustainability and innovation.	U, Ap	PSO-1,2,3,4
CO-6	Hands-on training by simple chemical experiments on related fields.	U, Ap	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: GENERAL CHEMISTRY III

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2	U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3,4	U, Ap	F, C, P	L	-
3	CO-3	PO-1,6 PSO-1,2,3,4	U, Ap	C, P	L	-
4	CO-4	PO-1,6 PSO-1,2,3,4	Ap, An	C, P	L	-
5	CO-5	PO-1,6	U, Ap	C, P	L	-

		PSO-1,2,3,4				
6	CO-6	PO-1,3,6 PSO-1,2,3,4	U, Ap	F, C	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	-	-	-	1	-	-	-	-	2		
CO 2	2	3	3	1	-	1	-	-	-	-	2		
CO 3	2	3	3	1	-	1	-	-	-	-	2		
CO 4	2	3	3	1	-	1	-	-	-	-	2		
CO 5	2	3	3	1	-	1	-	-	-	-	2		
CO 6	1	2	3	2	-	1	-	2	-	-	2		

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK3DSECHE200</td></tr>
<tr><td>Course Title</td><td colspan="5">ENVIRONMENTAL CHEMISTRY I</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">3</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical Per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>4 hours</td><td>-</td><td></td><td>4</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Fundamental concept of Environmental Chemistry
2. Terminology associated with Environment</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides students with the knowledge of ecosystem and the different types of pollution caused by human activities. This course enlightens the students about the need to protect and conserve our environment for future generation. The course also highlights the green protocols and methodology being adopted for preserving the Environment.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content **ENVIRONMENTAL CHEMISTRY I**	Hrs **60**
I	**ENVIRONMENT AND ITS COMPONENTS**		**9**
	1.1	Introduction, components of environment – biotic, abiotic and energy components	1
	1.2	environmental segments- atmosphere, hydrosphere, lithosphere and biosphere	1
	1.3	Biodistribution of elements.	1
	1.4	General Concepts of biological cycles – carbon cycle, nitrogen cycle, phosphorous cycle, Sulphur cycle and oxygen cycle	4
	1.5	Concepts and scope of environmental chemistry	1
	1.6	Environmental perspectives, environment and society	1
II	**ECOLOGY AND ECOSYSTEM**		**9**
	2.1	Ecology-elementary idea. Food chain- grazer and detritus food chain. Food web. Ecological pyramid.	***2***
	2.2	Ecosystem- concept, components, function and classification	2
	2.3	Productivity in an ecosystem- primary and secondary productivity	1
	2.4	Wetlands- elementary idea	1
	2.5	Biodiversity, sustainable ecosystem.	1

	2.6	Population and environment: Human population and distribution, urbanization	2
III	**ENERGY RESOURCES**		**9**
	3.1	Natural Resources-classification, Water resources, Forest resources, wood as a direct fuel, Land resources, Mineral resources, Energy resources	2
	3.2	Renewable and non-Renewable energy resources. Renewable energy resources - bio fuel & biomass energy, tidal energy, hydro power, wind energy wave energy, solar energy	3
	3.3	Hydrogen as a next generation fuel	1
	3.4	Nonrenewable energy resources - nuclear fuels and fossil fuels	1
	3.5	Conservation of natural resources. Future energy resources. Sustainable use of resources	2
IV	**ENVIRONMENTAL POLLUTION, ETHICS AND LAWS**		**18**
	4.1	Pollution- definition and its classification. Pollutants, classification of pollutants based on source and physical state	3
	4.2	Causes, effect and control measures of thermal pollution, nuclear pollution, noise pollution, marine pollution and Industrial pollution- Cement, textile, sugar, paper industry, fertilizer, leather, thermal and nuclear power plants	5
	4.3	Environmental ethics: Issues and possible solutions Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act	5
	4.4	Rio declaration, Montreal protocol, Kyoto protocol Environmental management-objectives and components. National conservative strategies, Environmental audit -Types	5
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
	1	Introduction to Environmental Components and segments	
	2	Concept of biological cycles and Food chain	
	3	Classification of Natural Energy Resources and its conservation	
	4	Classification of Pollutants and Types of Pollution	
	5	Introduction to environmental laws and legislation	

References

1. *Introduction to Environmental Chemistry*, Seventh Edition, New Age International Publishers
2. Gray W. van Loon & Stephen J. Duffy, *Environmental Chemistry*: A Global Perspective, Oxford University Press
3. H. Kaur, *Environmental Chemistry*, Pragati Prakashan
4. V.K Ahluwalia, *Environmental Chemistry*, Second Edition, Ane Books Pvt. Ltd.
5. Ronald A. Bailey, Herbert M. Clark, James P. Ferris, Sonja Krause, Robert L. Strong, *Chemistry of the Environment*, Second Edition, Academic Press

6 Asim K. Das, *Environmental Chemistry with Green Chemistry*, Books and Allied (P) Ltd.
7 G S Sodhi, *Fundamentals Environmental Chemistry*, Second Edition, Narosa Publishing House.

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Help to understand Environmental components, Environmental segments and various biogeochemical cycles	U	1,3
CO2	Understand the scope of environmental chemistry and investigate the relationship of society with environment	U	1,3
CO3	Help students to learn the dynamics of ecosystem including food chains, explore the importance of biodiversity and their need to conserve the biodiversity	U	1,3
CO4	Develop an understanding of various Energy resources and principles undertaken for the conservation of energy resources	U, R	1,3
CO5	Identifying the sources and types of environment pollution such as air pollution, water pollution, soil pollution Industrial pollution and exploring the relationship between Population and Environment	U, A	1,3
CO-6	Exploring the environmental laws and policy frameworks for protecting the environment and will reflect on ethical principles, values, and philosophies related to human interactions with the environment.	U	1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	F, C	L	
2	CO-2	1,3	U	C	L	
3	CO-3	1,3	U	F, C	L	
4	CO-4	1,3	U, R	F, C	L	
5	CO-5	1,3	U, A	F	L	

6	CO-6	1,2,3	U	F, C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

NO:	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 2	1	-	1	-	-	1	1	-	-	-	-	-	1
CO 3	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 4	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 5	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 6	1	1	1	-	1	1	1	-	-	-	-	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓			✓
CO 5	✓	✓		✓
CO 6	✓			✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK3DSECHE201</td></tr>
<tr><td>Course Title</td><td colspan="5">CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- I</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">3</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>4 hours</td><td>-</td><td></td><td>4</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Students should possess critical thinking skills to evaluate different energy resources objectively and analyze their advantages, disadvantages, and impacts.
2. Proficiency in using technology and understanding basic engineering principles will be helpful, especially when studying energy production technologies and their efficiency.</td></tr>
<tr><td>Course Summary</td><td colspan="5">▪ This course aims to thoroughly understand diverse energy resources, their characteristics, and associated advantages and disadvantages, facilitating informed decision-making in energy production and consumption.
▪ By exploring innovative technologies and critically evaluating energy strategies, students develop skills to address real-world environmental challenges and promote sustainable energy practices in various sectors.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content **CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- I**	Hrs 60
I		**BASIC CONCEPTS OF ENERGY RESOURCES**	**9**
	1.1	Introduction to Renewable Energy- Definition. Renewable Energy sources switching, Difference between Renewable & Non-renewable sources, Main sources – solar, wind, tidal, biomass, geothermal, Applications, Advantages & Disadvantages of Renewable Energy.	3
	1.2	Brief descriptions of solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, and oil shale. Introduction to the Internet of Energy (IOE)	3
	1.3	Green Energy: Introduction, Fuel cells: Classification of fuel cells – H_2; Zero energy concepts.	2
	1.4	Energy for household, industrial and agricultural uses, Fundamentals of energy development and energy-related pollution	1

II	**SUSTAINABLE AND NON-SUSTAINABLE ENERGY SYSTEM**		**18**
	2.1	Introduction to sustainable energy: Global energy challenges and need for sustainability	2
	2.2	Renewable energy sources, Energy conservation principle, Measurement of Industrial energy efficiency, Transportation efficiency and alternative fuels	2
	2.3	Environmental impact and Policy regulation, Environmental and social impacts.	2
	2.4	Energy storage technologies. Future trends in energy storage systems, Environmental impact of energy extraction, production, and consumption.	2
	2.5	Introduction to non-sustainable energy system. Classification of non-sustainable energy sources, Historical development and significance of fossil fuels and nuclear energy	3
	2.6	Fossil fuels and its importance; Coal, Pete, Tar sands, Oils, Oil shale, Natural gas; mitigating environmental impacts, and promoting energy security and resilience	3
	2.7	Basics of nuclear energy, nuclear forces, isotopes, and radioactivity, Type of radiations and their properties	2
	2.8	Nuclear fission and fusion reactions, nuclear power plant, nuclear fuel cycle, Nuclear safety and regulations	2
III	**CONVENTIONAL ENERGY SOURCES AND ENVIRONMENTAL CONSEQUENCES**		**9**
	4.1	Fossil fuels and air pollution. Overview of biomass as energy source; Biomass availability	1
	4.2	Environmental pollution associated with energy generation and consumption process	3
	4.3	Radioactive waste management, nuclear accident and their environmental impacts, Public perception and safety concerns	3
	4.4	Environmental consequences and climate change	2
IV	**ENERGY ASSESSMENT AND EVALUATION**		**9**
	5.1	Introduction to Energy audit assessment and survey	2
	5.2	Types of audits- walk-through- audit, preliminary energy audit, and detailed energy audit, Retro-commissioning, industrial energy assessment and Renewable energy assessment, Recommended practices	4
	5.3	Conducting the energy audit- details- computer simulation, developing the report	3
V	**OPEN ENDED MODULE: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams, etc**		**12**
	1.	Understand the different types of energy resources.	
	2.	Explore the characteristics and properties of each energy resource.	
	3.	Analyze the advantages and disadvantages of various energy resources.	
	4.	Explore innovative solutions and emerging technologies for sustainable energy production and consumption	
	5.	Analyze the environmental, social, and economic impacts of different energy sources.	
	6.	Any similar learning methods suggested by the faculty based on I-IV modules.	
	7.	Develop critical thinking skills to assess the feasibility and implications of various energy strategies.	

	8.	Evaluate the role of policy, technology, and behavior change in transitioning to sustainable energy systems.	
	9.	Evaluate participation in class discussions, case study analyses, and group projects.	
	10.	Encourage critical thinking and creativity in the development of solutions-oriented projects that address real-world environmental challenges associated with conventional energy sources.	

References

1. *Renewable Energy: Power for a Sustainable Future*, Godfrey Boyle, Oxford University Press, 2019.
2. *Solar Energy Engineering: Processes and Systems*, Soteris Kalogirou, Academic Press, 2021.
3. *Wind Energy Handbook*, Tony Burton, Nick Jenkins, David Sharpe, and Ervin Bossanyi, Wiley, 2020.
4. *Biomass for Renewable Energy, Fuels, and Chemicals* edited by Donald L. Klass, Academic Press, 2022.
5. *Geothermal Power Plants: Principles, Applications, Case Studies, and Environmental Impact* Ronald DiPippo, Butterworth-Heinemann, 2020.
6. *Fuel Cell Technology: Principles, Design, and Operation* Nigel Sammes, Wiley, 2021.
7. *Sustainable Energy: Choosing Among Options* Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, William A. Peters, and William D. Nordhaus, MIT Press, 2022.
8. *Environmental Science and Engineering* P. N. Palanisamy, S. M. Yasaswy, and D. Srikanth, McGraw Hill, 2020.
9. *Nuclear Energy: What Everyone Needs to Know* Charles D. Ferguson, Oxford University Press, 2021.
10. *Environmental Impact Assessment: Theory and Practice*, Peter Morris and Riki Therivel, Cambridge University Press, 2020.
11. *Energy Auditing and Energy Management Handbook*, Ali Hasanbeigi, Lynn Price, Elina Lin, and Hongyou Lu, Academic Press, 2021.
12. *Handbook of Energy Audits*, Albert Thumann, William J. Younger, and Terry Niehus, Fairmont Press, 2022.
13. *Renewable Energy: Power for a Sustainable Future*, Godfrey Boyle, Oxford University Press, 2019.
14. *Solar Energy Engineering: Processes and Systems*, Soteris Kalogirou, Academic Press, 2021.
15. *Wind Energy Handbook*, Tony Burton, Nick Jenkins, David Sharpe, and Ervin Bossanyi, Wiley, 2020.
16. *Biomass for Renewable Energy, Fuels, and Chemicals*, edited by Donald L. Klass, Academic Press, 2022.
17. *Geothermal Power Plants: Principles, Applications, Case Studies, and Environmental Impact* Ronald DiPippo, Butterworth-Heinemann, 2020.
18. *Fuel Cell Technology: Principles, Design, and Operation*, Nigel Sammes, Wiley, 2021.
19. *Sustainable Energy: Choosing Among Options*, Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, William A. Peters, and William D. Nordhaus, MIT Press, 2022.
20. *Environmental Science and Engineering*, P. N. Palanisamy, S. M. Yasaswy, and D. Srikanth, McGraw Hill, 2020.

Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To develop a better understanding of the fundamentals of energy resources, methods, and theories	U	1,3
CO-2	To illustrate the importance of renewable and non-renewable sources of energies	R, U	1,3
CO-3	To aware of the environmental consequences and remedies of conventional energy resources	R, U	1,3
CO-4	To understand and evaluate energy audit assessment and survey	E, An	1,3
CO-5	To encourage critical thinking and creativity in the development of solutions-oriented projects that address real-world environmental challenges associated with conventional energy sources.	E, C, An	1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO-1	1,3	U	C	L	
2	CO-2	1,3	R, U	F, C	L	
3	CO-3	1,3	R, U	F, C	L	
4	CO-4	1,3	E, An	F, C, P	L	
5	CO-5	1.2,3,5	E, C, An	F, C, P, M	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	3	-	-	2	3	-	-	-	-	-	-
CO 2	2	-	3	-	-	2	3	-	-	-	-	-	-
CO 3	3	-	3	-	-	3	3	-	-	-	-	-	-
CO 4	2	-	3	-	-	2	3	-	-	-	-	2	
CO 5	2	-	3	-	3	3	2	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓	✓	✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSECHE202**				
Course Title	**ANALYTICAL CHEMISTRY -I**				
Type of Course	**DSE**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4
Pre-requisites	1. General Chemistry 2. Equilibrium Principles				
Course Summary	This course provides students with the knowledge and skills necessary to understand the principles and practices of analytical chemistry, including the scope, function, and analytical perspective of the field. Students will learn about various analytical techniques, methods for sample preparation and analysis.				

Detailed Syllabus:

Module	Unit	Content ANALYTICAL CHEMISTRY -I	Hrs 60
I	**INTRODUCTION TO ANALYTICAL CHEMISTRY**		**9**
	1.1	Scope, function, The Analytical Perspective, Analytical Problems and their solutions, Trends in Analytical Methods and Procedures, Introduction to the terms used in analytical chemistry	3
	1.2	Qualitative and Quantitative Analysis, Sampling	2
	1.3	The analytical process: Steps in the analytical process	1
	1.4	Validation of a method, Use of literature, Analyze Versus Determine	3
II	**BASIC TOOLS OF ANALYTICAL CHEMISTRY**		**9**
	2.1	The Laboratory Notebook, Laboratory Basic Equipments & Measurements: Volumetric Glassware (Volumetric flasks, Pipets, Syringe pipets, Burets & Use of volumetric Glassware,) The Analytical Balance	2
	2.2	Units for Expressing Concentration**:** Molarity and Formality, Normality, Molality, Weight, Volume, and Weight-to-Volume Ratios, Converting Between Concentration Units, p-Functions	3
	2.3	Stoichiometric calculations, Selection of glassware, Preparation of standard acid & base solutions	2

	2.4	Other apparatus: Blood samplers, Desiccators, furnaces & ovens, hoods, wash bottles, Centrifuges & filters,	2
III	**LANGUAGE OF ANALYTICAL CHEMISTRY**		**9**
	3.1	Analysis, Determination, Measurement, Techniques, Methods, Procedures and Protocols, Classifying Analytical Techniques, Use of Literature	2
	3.2	Selecting an Analytical Method: Accuracy, Precision, Sensitivity, Selectivity, Robustness and Ruggedness, Scale of Operation, Equipment, Time, and Cost, Making the Final Choice	3
	3.3	Developing the Procedure & Standardizing Analytical Methods: Compensating for Interferences, Calibration and Standardization, Sampling, Validation, Analytical signals, Calibrating the signals, and Sensitivity determination.	3
	3.4	Protocols, The Importance of Analytical Methodology	1
IV	**CHEMICAL EQUILIBRIUM AND SEMIMICRO QUALITATIVE INORGANIC ANALYSIS**		**18**
	4.1	Reversible Reactions and Chemical Equilibria, Thermodynamics and Equilibrium Chemistry, Le-Chatelier's Principle, the law of mass action, Factors affecting chemical reactions in solutions	4
	4.2	Solubility product, Common Ion Effect, Fractional precipitation, Effect of acids, temperature and solvent on the solubility of a precipitate	4
	4.3	Introduction to semimicro qualitative inorganic analysis, The study of reactions of cations and anions on the semi-micro scale	3
	4.4	Preliminary tests, systematic analysis and Confirmatory tests for anions on the semi micro scale, Modifications of separation procedures in the presence of interfering anions	3
	4.5	Preparation of solution for cation testing, separation and identification of cations into groups (I, II A, II B, III A, III B, IV & V) on the semi micro scale	4
V	**Open Ended Module: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc.**		**30**
	1	Select an analytical method used in a specific industry (e.g., pharmaceuticals, environmental monitoring). Discuss the process of validation and standardization for this method, including the use of literature, compensating for interferences, and calibration techniques.	
	2	Identify, categorize, and describe the uses of apparatus and equipment commonly found in an analytical chemistry laboratory. Provide detailed explanations of the principles behind the operation of each instrument, as well as their applications in qualitative and quantitative analysis.	
	3	Perform stoichiometric calculations and demonstrate the selection and proper use of volumetric glassware, including volumetric flasks, pipettes, syringe pipettes, and burettes. Practice the preparation of standard acid and base solutions and conduct titrations to determine concentration.	
	4	Discuss the importance of proper instrument maintenance, calibration, and troubleshooting to ensure accurate and reproducible measurements.	

	5	Examine the theory and procedures involved in semi-micro qualitative inorganic analysis.	
	6	Discuss the systematic approach to testing for anions and cations, including preliminary tests, confirmatory tests, and separation techniques	
	7	Highlight the challenges and considerations in identifying and eliminating interfering groups.	

References

1. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Textbook of Quantitative Inorganic Analysis*, Longman, Fifth Edition, 1989.
2. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.
3. D. J. Holme and H. Perk, *Analytical Biochemistry*, 3rd edition, Prentice Hall, 1998.
4. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
5. D. A. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.
6. G. Svehla, *Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis*, Longman, 5th edition, 1979.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the scope, function, and analytical perspective of analytical chemistry, the steps involved in the analytical process, gain proficiency in validating analytical methods	U	1,3
CO-2	Learn units for expressing concentration, perform conversions between concentration units, and stoichiometric calculations and prepare standard acid and base solutions.	Ap, R	1,3
CO-3	Learn to select analytical methods, develop procedures and standardize analytical methods.	E	1,2
CO-4	Learn about the common ion effect and its impact on equilibrium, systematic analysis techniques on a semi-micro scale for cations and anions,	An	1,2

CO-5	Applies the knowledge in basics of Anlaytical chemistry and semimicro qualitative analysis in problem solving	Ap	1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL CHEMISTRY 1

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	F, C	L	
2	CO-2	1,3	Ap, R	C, P	L	
3	CO-3	1,2	E	C, P	L	
4	CO-4	1,2	An	C, P	L	
5	CO-5	1,2,3,5	Ap	M	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	3	-	-	-	1	2	-	-	-	-
CO 2	3	-	2	-	-	-	2	2	-	-	-	-
CO 3	2	2	-	-	-	-	3	2	-	-	-	-
CO 4	2	2	-	-	-	-	2	2	-	-	-	-
CO 5	3	2	2	-	3	-	3	2	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	√			√
CO 2	√			√
CO 3	√	√		√
CO 4	√			√
CO 5	√	√	√	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSECHE203**				
Course Title	**INDUSTRIAL CHEMISTRY-I**				
Type of Course	**DSE**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4
Pre-requisites	1. Fundamental concepts of chemistry. 2. Terminology associated with Industrial chemistry				
Course Summary	This course aims to equip students with a comprehensive understanding of various aspects of the chemical industry, including manufacturing processes, industrial applications, safety measures, and the principles of green chemistry, preparing them for careers in the chemical industry with a focus on sustainability and safety.				

Detailed Syllabus:

Module	Unit	Content INDUSTRIAL CHEMISTRY-I	Hrs
I	**INTRODUCTION TO INDUSTRIAL CHEMISTRY**		**9**
	1.1	Overview of Chemical Industry- Chemical sectors operating in India (Major sectors)	2
	1.2	Unit process, unit operations, flow diagrams, energy balance and material balance (basic concepts only)	3
	1.3	Chemical Industries in Kerala: Location, Raw materials, Chemistry involved in preparation, and uses- Sugar, Alcohol, TiO2, Glass, Cement, HCl, NaOH, Urea, Ammonium Phosphate and superphosphate of lime.	4
II	**INORGANIC CHEMICALS AND INDUSTRIAL GASES**		**9**
	2.1	Manufacture, Properties and uses of 1) Sulfuric acid, Phosphoric acid	2
	2.2	Manufacture, properties and uses of Industrial Gases: 1) Nitrogen 2) Oxygen 3) Carbon dioxide.	3
	2.3	Manufacture, properties and uses of inorganic nitrogen compounds: Ammonia, Nitric acid.	2
	2.4	Manufacture, properties and uses of Lime stone derivative: Lime, Sodium carbonate	2
III	**INDUSTRIAL ASPECTS OF ORGANIC CHEMISTRY**		**9**

	3.1	Primary raw materials for organic compounds- Petroleum and natural gas, Petroleum -origin of petroleum – mining of petroleum'-refining processes- Fractionation of crude oil	2
	3.2	Cracking: Thermal and catalytic Processes Reforming: Thermal and catalytic reforming Hydroforming: Conversion of hydrocarbons	3
	3.3	Coal Chemistry -Types, structure, and properties of coal	2
	3.4	Coking and gasification processes, distillation of coal- chemicals derived from them.	2
IV	**INDUSTRIAL HAZARDS, SAFETY MEASURES AND GREEN CHEMISTRY**		**18**
	4.1	Industrial hazards: Definition, Safety signs and colours used in industries	2
	4.2	Causes and preventive measures of: Mechanical hazard, Chemical hazard (Types) Fire Hazard, Dust hazard, Electrical hazard	4
	4.3	Introduction to Green Chemistry, Pollution prevention act of 1990, emergence of green chemistry, need for Green Chemistry	2
	4.4	Twelve principles of green chemistry	1
	4.5	Atom economy, safer solvents and auxiliaries, ionic liquids-super critical fluids CO2 and H2O, advantages of SCF	4
	4.6	Catalysis and green chemistry- bio catalysis	2
	4.7	Alternative sources of energy: use of microwaves and ultrasonic energy, Renewable resources – biomass, solar energy, hydropower, geothermal energy, tidal and wave energy	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, quizzes, open book exam etc.**		30
		1. Properties and applications of industrial gases and inorganic chemicals. 2. Specific unit processes and unit operations used in chemical industries, highlighting their principles, applications, and advancements. 3. Development of strategies to mitigate environmental impact and promote sustainability in chemical manufacturing. 4. Identification and resolution of safety hazards in chemical plants and laboratories. 5. Implementation of green chemistry principles to reduce the use of hazardous substances and energy consumption. 6. Role of renewable energy sources in powering chemical manufacturing processes. 7. Advancements in catalysis and its applications in green chemistry. 8. Innovative techniques for biomass conversion and utilization in the chemical industry. 9. Role of renewable energy sources in powering chemical manufacturing processes. 10. Chemistry and technology of petroleum refining and coal chemistry.	30

REFERENCES

1. *Riegel's handbook of industrial chemistry,* J.A.Kent, CBS Publishers, New Delhi

2. *Engineering Chemistry*, P.C.Jain, M.Jain Dhanpat Rai & Sons, Delhi
3. *Survey of Industrial Chemistry,Third Edition*,Philip J. Chenier Publications, New Delhi
4. *Engineering Chemistry*, B.K.Sharma, Goel Publishing House, Meerut
5. *Industrial Chemistry*, O. P. Vermani, A. K. Narula, Galgotia Publications Pvt. Ltd., New Delhi.
6. *The Text Book of Industrial chemistry,* Aashis Roy, 2018
7. *Industrial Safety Management*, 3rd Edition, Deshmukh. L.M., Tata McGraw Hill, New Delhi, 2008
8. *Chemical Hazards and Safety*, 2nd Edition, Shrikant Dawande, Khanna Publishers, 2012
9. *Industries in Kerala,* K.R.Rajan.
10. *Green Chemistry; Theory and Practice*, Anastas. P.T, Warner, J.C.,Oxford University Press, Oxford, U.K, 1998.
11. *Green Chemistry Environment Friendly Alternatives*, Rashmi Sanghi and M.M Srivasthava, Narosa Publishing House, 2006

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Analyze raw materials, processes, and industrial sectors in India, focusing on Kerala's chemical industries.	An	1,3
CO-2	Understand the production, properties and uses, of industrial gases and inorganic chemicals.	U	1,2
CO-3	Explain petroleum and coal processing methods and identify resulting chemical products.	U	1,2
CO-4	Implement safety measures for hazards in industries.	Ap	4
CO-5	Evaluate industrial processes using green chemistry principles and propose sustainable alternatives.	E	1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INDUSTRIAL CHEMISTRY-I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	An	C	L	

2	CO-2	1,2	U	C	L	
3	CO-3	1,2	U	C	L	
4	CO-4	4	Ap	P,C	T	
5	CO-5	1,2	E	C	T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	3	-	3	-	2	3	3	-	-	-	-	-	-
CO 2	3	-	1	-	-	3	3	2	-	-	-	-	-
CO 3	3	3	-	-	-	3	3	-	-	-	3	-	-
CO 4	-	-	2	-	-	3	3	-	-	-	-	-	-
CO 5	3		3	3	-	3	3	2	-	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSECHE204**				
Course Title	**POLYMER CHEMISTRY I**				
Type of Course	**DSE**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Higher secondary level chemistry				
Course Summary	The course delas with polymer chemistry, students delve into the historical development, classification, methods of polymerization, and diverse applications of polymers, including plastics, engineering plastics, elastomers, and fibers. Through problem-solving exercises, seminars, open discussions, and assessments, students gain a deep understanding of polymer synthesis, structure-property relationships, and real-life applications,				

Detailed Syllabus:

Module	Unit	Content **POLYMER CHEMISTRY I**	Hrs 60
I	**BASIC PRINCIPLES OF POLYMER CHEMISTRY**		**12**
	1	Historical development of polymer chemistry. Monomers, polymers, repeating units, functionality.	2
	2	Nomenclature of polymers. Importance and applications of polymers – acrylic, vinyl, cellulose, fluorinated, poly ethylene, & SAN copolymer.	4
	3	Classification of polymers. Ladder and spiral polymers. Cis- trans configuration. DL isomers and tacticity.	3
	4	Inorganic polymers- importance, advantages and applications- structure, preparation and properties of silicones and polyphosphazenes. Comparison with organic polymers.	3
II	**METHODS OF POLYMERIZATION**		**18**
	1	Free radical addition polymerization - Chain growth polymerization. Mechanism of chain growth polymerization. Initiation, propagation and termination. Types of free radical initiators (peroxo, azo and redox initiators). Initiator efficiency. Inhibitors and retarders – functions and examples. Chain transfer reactions.	4

	2	Ionic polymerization – anionic and cationic catalysts, Solvent effects in ionic polymerizations. Mechanism of anionic and cationic polymerizations. Counter ions. Termination modes. Living polymers.	4
	3	Coordination polymerization: stereo regularity, Ziegler-Natta catalysts. Metallocene catalysts. Bimetallic and monometallic mechanisms.	3
	4	Condensation or step growth polymerization-Average functionality, basic characteristics, extent of reaction, degree of polymerization	3
	5	Copolymerization: random, alternate, block and graft. Copolymerization involving two monomers (free radical mechanism). Polymerisation techniques (bulk, solution, suspension and emulsion). Melt, solution and interfacial condensation.	4
III	**PLASTICS AND ENGINEERING PLASTICS**		**9**
	1	Preparation, structure and properties of polyolefins (LDPE, HDPE, LLDPE and PP); vinyl polymers (PVC, Polyvinyl acetals and PMMA);	3
	2	Teflon and polyurethanes; Phenol formaldehyde and urea formaldehyde resins; nylons and polyesters (Terylene and Dacron).	2
	3	Engineering plastics, ABS, polyamides, polycarbonates, PPO, PPS, polysulphones, polyimides, polyesters, flouropolymers, ionomers, and liquid crystalline polymers.	4
IV	**ELASTOMERS AND FIBRES**		**9**
	1	Natural rubber, composition, preservation & coagulation of latex, Structure, properties and preparation of synthetic rubbers (PB, SBR, NBR, polychloroprene, polyisobutylene, IIR, EPDM, buna-N, thiacol). Reclaimed rubbers.	5
	2	Thermoplastic elastomers- advantages, polyurethanes.	2
	3	Fibres: natural (structure and properties); synthetic (structure and properties of nylon, polyester and acrylics)	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions on real life applications, assignment discussions, Quizzes, Open book exams, etc on the above four modules.**		**12**

References:

1. Billmeyer, "*Textbook of polymer science*", John Wiley and Sons.
2. D.D. Deshpande, "*Physical chemistry of macromolecules*", Vishal publications, New Delhi, 1985.
3. V.R. Gowariker, N.V. Viswanathan and J. Sreethan, "*Polymer Science*", Wiley Eastern Ltd, 1986.
4. K.J. Saunders, *Organic Polymer Chemistry*, 2^{nd} Edn., Chapman and Hall, London, 1988.
5. Gowri Sankar Misra, *Introductory Polymer Chemistry*, New Age International, New Delhi.
6. P Ghosh, *Polymer Science & Technology*, Tata McGraw Hill Education, 1991.
7. Jeol R. Fried, *Polymer Science & Technology*, Prentice Hall of India (P) Ltd. New Delhi, 1999.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Differentiate between Natural and synthetic polymers	U	PSO-1,2,3
CO-2	Understand polymerization process of monomeric units	U	PSO-1,2,3
CO-3	Critically analyse the advantages and disadvantages of polymers	An	PSO-1,2,3,4
CO-4	Analyse different Applications of Polymers	An	PSO-1,2,3
CO-5	Enhance problem-solving and critical thinking skills, by applying the knowledge of polymer chemistry to address practical challenges	Ap, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: POLYMER CHEMISTRY I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO-1	PO-1,2,6 PSO-1,2,3	U	F, C	L	
2	CO-2	PO-1,2,6 PSO-1,2,3	U	F, C	L	
3	CO-3	PO-1,2,6 PSO-1,2,3,4	An	C	L	
4	CO-4	PO-1,2,6 PSO-1,2,3	An	P	L	
5	CO-5	PO-1,2,3,6 PSO-1,2,3,4,5	Ap, E	P	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	2	-	-	2	1	-	-	-	1	-	-
CO 2	2	3	2	-	-	1	1	-	-	-	2	-	-
CO 3	2	2	3	2	-	2	1	-	-	-	2	-	-
CO 4	2	1	2	-	-	2	2	-	-	-	2	-	-
CO 5	1	2	2	1	2	3	2	-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3DSECHE205**				
Course Title	**FORENSIC CHEMISTRY I**				
Type of Course	**DSE**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Higher secondary level science knowledge				
Course Summary	The course covers topics including Criminology, Domains in Forensic Science, Forensic Laboratoriesat National and International levels and Forensic Institutions- their Role, Functions, Services, and Functionalities, Legal Provisions Related to Forensic Science				

Detailed Syllabus:

Module	**Unit**	**Content** **INTRODUCTION TO FORENSIC SCIENCE**	**Hrs** **60**
I	**CRIMINOLOGY**		**9**
	1.1	Crime: Definition of crime, history and development, victimology, criminological perspective	2
	1.2	Characteristics of crime, classification of crimes: White collar crime, professional crime, organized crime.	2
	1.3	Crime against persons, property and State- present scenario of crime in India	2
	1.4	Criminal and Criminology: Definition of criminal, classification of criminals	2
	1.5	Definition of criminology, growth of criminology in India	1
II	**INTRODUCTION TO FORENSIC SCIENCE- I BASIC PRINCIPLES**		**12**
	2.1	Introduction, Definition, need, significance and scope of Forensic Science	2
	2.2	Principles of Forensic Science, multi professional and multi personal aspects of forensic science.	2
	2.3	Domains in Forensic Science: Forensic Biology, Forensic Medicine, Forensic Toxicology,	2
	2.4	Forensic Osteology and Odontology, Forensic Physics.	2

	2.5	Forensic Photography, Ballistics, Fingerprint, Questioned Documents	2
	2.6	Forensic Psychology, Forensic Anthropology, Wild-life Forensics, DNA profiling, Computer Forensic etc.,	2
III	**FORENSIC LABORATORIES AND FORENSIC INSTITUTIONS-ROLE, FUNCTIONS**		**15**
	3.1	Historical Development and Growth of Forensic Science Laboratories in India – Central and State Level Laboratories, Services and Functionalities provided by various FSLs, Various Divisions of the FSL	2
	3.2	Qualifications of forensic scientists. Duties of forensic scientists.Functions of Forensic Scientist, Police officers, Prosecution, Judicial Officers, and Medico legal expert etc.	3
	3.3	Problem of proof in Forensic Science, Ethical issue in Forensic Science: Definition of ethics, professional standards for practice of Criminalistics, sanction against expert for unethical conduct	3
	3.4	Historical Development of Police System in India. Police in Indian Constitution	2
	3.5	Objective ofPolice, General organization of Police-Forensic science in national international perspectives, including set up of INTERPOL and FBI.	3
	3.6	Various institutions and their functioning- NFSU, NCRB, CDTS, CCMB, CDFT, NTRO etc	2
IV	**LEGAL PROVISIONS RELATED TO FORENSIC SCIENCE**		**12**
	4.1	Definition of Law, Court, Judge, Crime and Criminal, Basic Legal Terminology-Constitution of India: Preamble, Article 20, 21, 22	3
	4.2	Offences person, property, and state- relevant section in IPC/BNS	3
	4.3	Indian Evidence Act/BSS- Sections 32, 45, 46, 47, 57, 58, 60, 73, 135, 136, 137, 159.	3
	4.4	Criminal Procedure Code/BNSS: Sections 291, 292, 293.	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
		1. Seminars with legal experts 2. Assignments on news paper crime reports 3. Visit to Laboratories 4. Debates on present crime issues	

References

1. Richard Saferstein**:** *Criminalistics: An Introduction to Forensic Science*, Pearson Publishing,
2. Brent E. Turvey, *Criminal Profiling: An Introduction to a Behavioral Evidence Analysis*, Academic Press

3. Sharma, B.R; *Forensic Science in Criminal Investigation & Trials*, Universal Publishing Co., New Delhi, 2003
4. Nanda B.B and Tewari, R.K; *Forensic Science in India- A vision for the Twenty First Century*, Select Publisher, New Delhi, 2001.
5. Houck, M.M & Siegel, J.A; *Fundamentals of Forensic Science*, Academic Press, London, 2006.
6. James, S.H and Nordby, J.J; *Forensic Science- An Introduction to Scientific and Investigative Techniques*, CRC Press, USA, 2003.
7. Bag, R.K. *Supreme Court on Criminal Law*. Asia Law House: (1999).
8. Deb, R. *Criminal Justice*. The Law Book Co. Pvt. Ltd: Allahabad; (1998).
9. Gross, H. Criminal Investigation- *A Practical Handbook for Magistrates, Police Officers and Lawyers*. Forgotten Books: India; (2000).
10. *The Indian Evidence Act (1872), Amendment Act (2002*), Universal Law Publication: (2003).

Course Outcomes

SI No	Course Outcome: Upon completion of this course the student will be able to	Cognitive Level	PSO
1	Illustrate the basics of crime and types of crime, Criminology, Criminology in India.	U	5
2	Demonstrate the basic principles of forensic science, principles and various domains.	U	3
3	Recognizes the role and functions of forensic laboratories and forensic Institutions.	R	3,5
4	Identify the legal provisions available in India related to forensic Science	A	3
5	Classify the different crimes and role of forensic science in solving	Ap	5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FORENSIC CHEMISTRY I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	5	U	C	L	
2	CO-2	3	U	F, C	L	
3	CO-3	3,5	R	F, C, P	L	

4	CO-4	3	A	F, C, P	L	
5	CO-5	5	Ap	F, C, P, M	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PS O5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	2	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	-	-	-	-	-	-	-	-	3	-	-	-	

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY
Course Code	**UK3DSECHE206**
Course Title	**CHEMISTRY OF NANOMATERIALS -I**
Type of Course	**DSE**
Semester	3
Academic Level	200-299

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours			4

Pre-requisites	Higher secondary Chemistry
Course Summary	This course covers the fundamental principles of materials science and engineering, including atomic structure, crystallography, mechanical properties, electrical properties, thermal properties, and magnetic properties. It also explores the synthesis, processing techniques of materials and it's vide applications in various fields**.**

Detailed Syllabus:

Module	Unit	Course Description CHEMISTRY OF NANOMATERIALS -I	Hrs 60
I	**INTRODUCTION TO MATERIALS SCIENCE**		**9**
	1.1	Definition and scope of materials chemistry	3
	1.2	Historical Perspective	1
	1.3	Classification of Materials- Metals and alloys, Polymers, Ceramics and glasses, Composites, Advanced Materials- Semiconductors, Biomaterials, Smart materials, Nanomaterials	3
	1.4	Importance of materials chemistry in technology and industry	2
II	**ATOMIC AND MOLECULAR STRUCTURE OF MATERIALS**		**9**
	2.1	Introduction, Atomic Structure-Fundamental Concepts	1
	2.2	Bonding Forces and Energies- Primary Interatomic Bonds- Ionic, covalent, metallic bonding; Secondary bonding or Vander Waal's forces	2
	2.3	Structure of Crystalline Solids- Fundamental concepts Bravais lattices, unit cell, Crystal systems, Crystallographic Points, directions, and Planes Closed Packed Crystal structures- BCC, FCC, HCP	3
	2.4	Defects in Crystals: Imperfections and their impact on properties.	3
III	**PHYSICAL PROPERTIES OF MATERIALS**		**9**
	3.1	Mechanical properties- Stress, strain, and elastic deformation, Tensile testing - Plastic deformation	2

	3.2	Thermal properties - Heat capacity and thermal conductivity; Thermal expansion and its measurement	2
	3.3	Optical properties - Reflection, refraction, and dispersion, Absorption and transmission of light	2
	3.4	Electrical & Magnetic Properties- Conductivity, resistivity Dielectric materials and polarization Magnetic materials -Ferromagnetism, paramagnetism, and diamagnetism	3
IV	**SYNTHESIS, PROCESSING AND APPLICATIONS OF MATERIALS**		**18**
	4.1	Solid-state reactions Powder preparation methods (milling, comminution) Sintering and densification techniques	2
	4.2	Gas-Phase Reactions Chemical vapor deposition (CVD), Physical vapour deposition (PVD) Plasma-enhanced CVD Physical vapor deposition (PVD) techniques (sputtering, evaporation)	3
	4.3	Liquid phase reactions Sol-gel processing, Hydrothermal, solvothermal Chemical vapor deposition (CVD) Electroplating and electroless deposition Spin coating and dip coating	2
	4.4	Emerging Processing Techniques Additive manufacturing (3D printing) Self-assembly and biomimetic synthesis	2
	4.5	Electronic and Optoelectronic Applications Applications in microelectronics, photonics, and telecommunications	2
	4.6	Materials for Energy storage and Conversion: Energy Storage Materials: Batteries, supercapacitors, and fuel cells Energy Conversion Materials: Solar cells, thermoelectric materials, and hydrogen storage materials	3
	4.7	Biomaterials and Medical Applications Implants, prosthetics, medical devices, drug delivery systems, tissue engineering and regenerative medicine	2
	4.8	Environmental and Sustainable Applications Recycling, green materials, and sustainable manufacturing Materials for pollution control, water treatment	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		12
		1.Defention and scope of material chemistry 2. Importance of materials chemistry in technology and industry 3. Bravais lattices, unit cell, Crystal systems 4.Closed Packed Crystal structures- BCC, FCC, HCP 5.Mechanical, thermal, optical, electric and magnetic properties of materials 6. Emerging Processing Techniques of materials 7. Materials for Energy storage and Conversion 8.Applications of materials in various fields	

References

1. W.D Callister. Jr, *Materials Science and Engineering*, Wiley India Pvt. Ltd, 2007
2. Raghavan V, *Materials Science and Engineering*, 4th Edition, Prentice Hall of India, 1998
3. Joel I. Gersten and Frederick W. Smit, "*The Physics and Chemistry of Materials*", Wiley, 2007
4. Fahlman, B.D., *Materials Chemistry*, Springer, 2007
5. James F. Shackelford, *Introduction to Materials Science for Engineers*, 8th Edition, 2020
6. William F. Smith and Javad Hashemi, *Foundations of Materials Science and Engineering*; 6th Edition, Mc Graw Hill, 2022

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students will get to know the different classes of materials and its importance in technology and industry	U	1,3
CO-2	Understand the interatomic bonding in solids and the type of bond allows them to explain a material's properties	R, U	1,2
CO-3	Describe the difference in atomic/molecular structure between crystalline and noncrystalline materials.	U	1,2,3
CO-4	Describe how face-centered cubic and hexagonal close-packed crystal structures may be generated by the stacking of close-packed planes of atoms. Identify the imperfections in crystals	Ap	1,3
CO-5	Define and differentiate between various physical properties of materials, including mechanical, thermal, optical, and magnetic properties.	U	1,2,3
CO-6	Describe the fundamental principles and various techniques involved in the synthesis of materials, encompassing metals, ceramics, polymers, and composites.	U	1,2,3,5
CO-7	Relate the material properties (mechanical, thermal, optical, electrical, etc.) to their suitability for specific applications.	U	1,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY OF NANOMATERIALS -I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	F, C	L	
2	CO-2	1,2	R, U	C	T	
3	CO-3	1,2,3	U	C	L	
4	CO-4	1,3	Ap	F, C	L	
5	CO-5	1,2,3	U	M	T	
6	CO-6	1,2,3,5	U	C	L	
7	CO-7	1,3,5	U	M	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	3	-	-	2	1	-	-	-	-	-	-
CO 2	3	3	-	-	-	3	2	-	-	-	-	-	-
CO 3	2	1	3	-	-	3	2	-	-	-	-	-	-
CO 4	3	-	2	-	-	2	2	-	-	-	-	-	-
CO 5	3	3	2	-	-	3	3	-	-	-	-	-	-
CO 6	3	2	3	-	3	3	3	-	-	-	-	-	-
CO7	2	-	3	-	2	3	2	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓	✓	✓
CO 5	✓	✓		✓
CO 6	✓		✓	
CO 7	✓		✓	

University of Kerala

Discipline	CHEMISTRY
Course Code	**UK3DSECHE207**
Course Title	**MEDICINAL AND PHARMACEUTICAL CHEMISTRY I**
Type of Course	**DSE**
Semester	3
Academic Level	200-299

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4

Pte-requisites	Basic knowledge on organic chemistry
Course Summary	Introduction to the drug discovery process, Historical perspectives and milestones, Importance of drug discovery in healthcare. Opportunities for innovation in this field. This course outline provides a comprehensive overview of the stages of drug discovery, from lead discovery to regulatory considerations, while also covering essential concepts such as pharmacokinetics and familiarize the pharmacological terms involved.

Detailed Syllabus:

Module	Unit	Content MEDICINAL AND PHARMACEUTICAL CHEMISTRY I	Hrs 60
I	**DRUG DESIGN AND DEVELOPMENT**		**9**
	1.1	Drug discovery- Introduction to Stages of drug discovery-Target identification, Target validation	2
	1.2	Definition of Lead in drug Discovery-Steps in Lead identification, Lead optimization	2
	1.3	Search for lead compound-bioactive compounds from natural source, Accidental lead discovery (Pencillin, sidenafil, insulin)	2
	1.4	Metabolites-Examination of metabolite- exploitation of side effects of drug- Need of Molecular modification-reduce toxicity, lipid solubility, alter metabolism, orally active compound	3
II	**TERMINOLOGIES OF DRUG DISCOVERY AND PHARMACOLOGICAL ACTIVITY**		**18**
	2.1	Objectives of Pharmacodynamics	2
	2.2	Terminologies – drug, pharmacognosy, pharmacy, pharmacology, pharmacokinetics-ADMET properties,	3
	2.3	Clinical pharmacology, pharmacotherapeutics, chemotherapy, toxicology	2
	2.4	Antimetabolites, Mutation, Bacteria, Virus, Fungi, Actinomycetes	1

	2.5	Pharmacophore, vaccines, pharmacopeia, posology and therapeutic index. Sources of drugs – dosage forms – bio availability, Lipinski's rule of five	3
	2.6	Routes of administration of drug – absorption, distribution and elimination of drugs	1
	2.7	drug metabolism – Structure and pharmacological activity	3
	2.8	Effect of – unsaturation, chain length, isomerism; - halogens, amino, nitro, acidic, Effect of groups - aldehydic, keto, hydroxyl and alkyl groups.	3
III	**CLASSIFICATION OF DRUG**		**9**
	3.1	Definition, history, present status and scope of Pharmacognosy	2
	3.2	Elementary idea on classification of drugs: Alphabetical -Taxonomical - Pharmacological - Chemical - Chemo-taxonomical	4
	3.3	Quality control of crude drugs: Different methods of adulteration of crude drugs - Evaluation of crude drugs	3
IV	**TRADITIONAL AND MODERN METHODS OF DRUG DEVELOPMENT**		**9**
	4.1	Drug-Discovery and development in the -Past, Present; Comparison of traditional and modern methods of development of drugs –	2
	4.2	Drug design by method of variation – disjunction and conjunction methods.	2
	4.3	Some important Indian medicinal plants – Tulsi, Neem, Kizhanelli, Semparuthi, Panikoorka, Adadodai, Turmeric and Panikoorkka uses-Common diseases and their treatment	5
V	**OPEN ENDED MODULE: Learning through Discussion, Assignment, Presentation, Quizzes, Open book exams etc**		**12**
	1	Provide examples of successful target identification and validation processes in drug discovery. Ask students to analyze these cases and discuss the importance of target selection	2
	2	students research the stories behind the accidental discoveries till now and discuss the implications for modern drug discovery	2
	3	Assignment to identify the medicinal plants of regional importance and find the major bioactive metabolites	2
	4	Conduct power point presentation on classification of drugs elucidating two examples each based on Alphabetical -Taxonomical - Pharmacological - Chemical - Chemo-taxonomical	2
	5	Conduct quiz on regional name and botanical name of various medicinal plants of Ayurvedic importance	1

Reference:

1. Patrick, G.L. (2013). *Introduction to Medicinal Chemistry* (5th Edition). UK: Oxford University Press.
2. Hakishan, V.K. Kapoor, (2017). *Medicinal and Pharmaceutical Chemistry*, New Delhi:Vallabh Prakashan. Pitampura

3. Jayashree Ghosh, (1999), *A text book of pharmaceutical chemistry*, 2nd ed., S.Chand& company, New Delhi.
4. Chatwal G R, (1991), *Pharmaceutical chemistry, organic (vol-II).*, Himalaya publishing house, Bombay.
5. D.Sriram & P.Yogeeswari, *Medicinal Chemistry* 2^{nd} Edition
6. Patrick G, (2002), *Instant Notes Medicinal Chemistry*, Viva Books Private Limited, New Delhi.
7. *Medical pharmacology* Padmaja Udayakumar, CBS Publishers and Distribution Pvt Ltd
8. *Principles of Medicinal Chemistry: Modern Methods in Drug Design":* John Smith, Emily Johnson: Wiley,2020.

Course outcome

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamentals of Drug Design and its importance in this present scenario. Familiarize the terms involved in the drug discovery process	R, U	PSO-5,3
CO-2	Apply the importance of functional group and the structure of compounds in various pharmacological activity.	A, C	PSO-1,3
CO-3	Differentiate Traditional and Modern methods of Drug discovery process appreciate the technology involved in latest drug discovery process	An	PSO-1,5
CO-4	These topics equip students with a comprehensive understanding of natural drugs, their origins, chemical constituents, pharmacological actions, and therapeutic applications	U, Ap	PSO1,3
CO-5	These tasks provide a comprehensive understanding of various aspects of drug discovery, from target identification to drug classification and traditional medicine. They foster critical thinking, research skills, and an appreciation for the complexities of modern pharmacology.	U, Ap, E	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: MEDICINAL AND PHARMACEUTICAL CHEMISTRY I

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-5,3	R, U	F	L	-
2	CO-2	PSO-1,3	A, C	C, P	L/T	-
3	CO-3	PSO-1,5	An	F, C	L/T	-
4	CO- 4	PSO1,3	U, Ap	C, P	L	-
5	CO- 5	PSO-1,2,3	U, Ap, E	C, P	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	-	2	-	1	-	-	1	2	-	-	-	-
CO 2	1	-	3	-	-	2	-	-	-	-	-	-	-
CO 3	2	-	-	-	2	-	-	2	-	-	-	-	-
CO 4	3	-	2	-	-	3	-	-	-	-	-	-	-
CO 5	1	2	1	-	-	-	-	-	-	3	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓	✓	✓
CO 5		✓		
CO 6		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK3VACCHE200**				
Course Title	**LABORATORY SAFETY**				
Type of Course	**VAC**				
Semester	3				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic science knowledge and interest in chemistry				
Course Summary	This course provides comprehensive training on laboratory safety protocols, chemical hazards, proper handling of chemicals and apparatus, safety equipment usage, emergency procedures, and laboratory waste management, with a focus on Indian regulations and challenges. Students will gain essential knowledge and skills to ensure safe and responsible practices in chemical laboratories, emphasizing compliance with legal frameworks and environmental protection.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		LABORATORY SAFETY	**45**
I		**INTRODUCTION TO LAB SAFETY**	**6**
	1	Introduction, Eye Protection-Clothing- Gloves, Laboratory Protocol - Laboratory Visitors - Comportment in the Laboratory	3
	2	Housekeeping-Cleaning Glassware - Inhaling Harmful Chemicals – Distillations – Extraction – Refrigerators - Disposal - General Disposal Guidelines.	3
II		**CHEMICAL HAZARDS**	**6**
	3	Toxicity, Explosivity, Flammability, Corrosivity, Exposure Limits, Sources of Information, Material Safety Data Sheets (MSDSs), Understanding an MSDS, Labels, Reading MSDSs and Labels, Physical hazards, Environment hazards and symbols	3
	4	The Properties of Chemicals, Learning Chemistry from an MSDS, Classifying Hazardous Chemicals - Solvents and Their Hazards - Acids and Bases - A Few Examples of Toxic Materials - Organic Peroxides	3

		and Peroxide Formers, Physical hazards, Environment hazards and symbols	
III	**WORKING WITH CHEMICALS AND APPARATUS**		**9**
	5	Equipment Use - Laboratory Hoods, Precautions for Using Electrical Equipment, Centrifuges, Using Steam, Using High-Pressure Air, Ultraviolet Lamps.	4
	6	Controlling Temperature - Oil and Sand Baths, Cooling Baths and Cold Traps, Dry Ice Cooling Baths and Cold Traps, Cryogenic Liquid Cooling Baths and Cold Traps, Working with Reduced Pressure.	5
IV	**SAFETY EQUIPMENT, EMERGENCY PROCEDURES & LABORATORY WASTE MANAGEMENT**		**15**
	7	General Information, Fires - Fire Prevention, dealing with a Fire, Personal Injuries Involving Fires	3
	8	Chemicals on Skin, Clothing, and Eyes, Other Personal Injury Accidents, Spill Cleanup	4
	9	Introduction to waste management, Chemical waste disposal, glass disposal, emergency procedures, Response to incidents and accidents	3
	10	Indian regulations on chemical and hazardous waste management, Brief idea on Legal Framework on Chemical and Hazardous Waste in India, Issues and Challenges in Production, Storage and Transport of Chemicals in India:	5
V	**OPEN ENDED MODULE:**		**9**
	11	Seminar presentations, group discussions, debates, quizzes, case studies etc on the above modules - searching for safety equipments and identify potential hazards in the lab - case studies involving lab accidents or safety violations – Inspections in the lab for safety hazards - Creative and practical designs and innovative ideas for personal protection, hazard warnings, emergency response systems etc. **(Or any other related activities introduced by the teacher)**	

References

1. *Safety in Academic Chemistry Laboratories, volume 1, Accident prevention for college and university students*, 7th Edn (ISBN 0-8412-3863-4), American Chemical SocietyWashington, DC.
2. *Techniques of Safety Management* (ISBN: 978-18-8-558139-6), Dan Petersen, McGraw-Hill Book Co. Ltd., New York, N.Y. USA.
3. *Hazardous Chemical Data Book* (ISBN:081-551072-1), G. Weiss, Noyes Data Corporation, Park Ridge, New Jersey, N.Y. (USA).
4. *Environmental Health & Safety Management*, Nicholas & Madelyn, Jaico Publishing House, Mumbai.
5. *Hazardous waste management, Volume II, Characterisation and treatment process*, Sukalyan Sen Gupta.
6. *Solid and Hazardous waste management*, 2nd edition, M.N.Rao.
7. *Handbook on chemicals & hazardous waste management & handling in India*, MOEFCC.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Proficiency in implementing laboratory safety measures, including proper attire and eye protection, adherence to laboratory protocols, and maintaining a safe environment	U, An, Ap	PSO-2,3,4,5
CO-2	Identify physical and environmental hazards and symbols associated with various substances.	An, Ap	PSO-2,3,4,5
CO-3	Proficiency in the safe and effective use of laboratory equipment and temperature control methods	An, Ap	PSO-2,3,4,5
CO-4	Competence in fire safety protocols, including prevention measures, effective response to fires, and procedures for managing personal injuries caused by fires or chemical exposure	Ap, E	PSO-2,3,4,5
CO-5	Proficiency in waste management practices and effective response to incidents and accidents in laboratory settings	Ap, E	PSO-2,3,4,5
CO-6	Gain an understanding of Indian regulations governing chemical and hazardous waste management and legal framework, issues, and challenges related to the production, storage, and transport of chemicals.	U, An	PSO-2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: LABORATORY SAFETY

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,2,3,6,8 PSO-2,3,4,5	U, An, Ap	C, P	L	-
2	CO-2	PO-1,2,6,8 PSO-2,3,4,5	An, Ap	C, P	L	-

3	CO-3	PO-1,2,3,6,8 PSO-2,3,4,5	An, Ap	C, P	L	-
4	CO-4	PO-1,2,3,6,8 PSO-2,3,4,5	Ap, E	P, M	L	-
5	CO-5	PO-1,2,3,6,8 PSO-2,3,4,5	Ap, E	P, M	L	-
6	CO-6	PO-1,2,3,4,6,8 PSO-2,3,4,5	U, An	C, P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO2
CO 1	-	1	3	3	2	1	2	2	-	-	2	-	2
CO 2	-	1	3	3	2	2	2	1	-	-	2	-	2
CO 3	-	1	3	3	2	1	2	2	-	-	3	-	2
CO 4	-	1	3	3	2	1	2	1	-	-	2	-	2
CO 5	-	1	3	3	2	2	1	1	-	-	3	-	2
CO 6	-	1	2	3	1	1	1	2	2	-	2	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓		✓	

SEMESTER 4

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSCCHE200**				
Course Title	**INORGANIC CHEMISTRY II**				
Type of Course	**DSC**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	4 hours	6
Pre-requisites	1. Higher secondary level chemistry 2. UK1DSCCHE100 (preferable)				
Course Summary	This course offers a comprehensive study of compounds of non-transition elements, covering various topics such as glass manufacturing, boron compounds, phosphorus oxides, halogen compounds, noble gases, inorganic polymers, and nuclear chemistry. Additionally, it includes practical experiments in inorganic qualitative analysis and preparations of inorganic compounds, providing students with hands-on experience in the laboratory.				

Detailed Syllabus:

Module	Unit	Content INORGANIC CHEMISTRY II	Hrs 90
I	**COMPOUNDS OF NON-TRANSITION ELEMENTS**		**12**
	1	-Manufacture and uses of the following Glass -different types of glasses, silicates, zeolites and silicones.	3
	2	-Borax - boron hydrides, boron nitrides, borazole and carboranes -Oxides and oxyacids of phosphorus.	2
	3	-Refractory carbides, nitrides, salt like carbides, borides and silicides.	1
	4	-Oxides and oxyacids of halogens (structure only) - Inter halogen compounds -pseudo halogens	2
	5	-Noble gases-uses, Xenon compounds– structure and hybridization in Xenon flourides and oxyflourides	2
	6	-Important inorganic polymers, phosphorus, boron and silicon based polymers-structure and industrial applications.	2
II	**NUCLEAR CHEMISTRY**		**6**
	7	Nuclear Stability and Decay Modes - Nuclear stability: factors influencing nuclear stability, neutron-to-proton (n/p) ratio - Modes of decay: alpha (α), beta (β), and positron emission	1

		- Packing fraction, mass defect, and binding energy	
	8	Fundamentals of Radioactivity - Introduction to natural radioactivity - Decay constant: definition and significance - Half-life and average life: definitions and calculations - Derivation of decay constant (brief overview, not detailed derivation)	1
	9	Disintegration Series and Modes of Decay - Overview of disintegration series - Artificial transmutation and artificial radioactivity	1
	10	Units and Measurement of Radioactivity - Units of radioactivity and Measurement using GM counter, Wilson cloud chamber, and scintillation counter	1
	11	Nuclear Reactions and Applications - Nuclear fission and fusion: atom bomb and hydrogen bomb - Applications of radioactivity: 14C dating, rock dating, neutron activation analysis, isotope tracers, dosimetry	1
	12	- Application of radioactive isotopes in medicine: radio diagnosis and radiotherapy - Merits and demerits of nuclear technology: environmental impact, safety concerns, energy production.	1
III	**CHEMISTRY OF NANO MATERIALS**		**6**
	1	Evolution of Nanoscience - Historical overview of nanoscience: from ancient times to the modern era - Key milestones and discoveries in nanoscience and nanotechnology - Contributions of early scientists and researchers to the development of nanoscience	1
	2	Preparations of Nanoparticles - Introduction to nanoparticle preparation methods - Top-down approaches: techniques such as lithography and etching - Bottom-up approaches: methods including sol-gel synthesis, colloidal precipitation, coprecipitation, combustion techniques, sonochemistry, hydrothermal technique, and high-energy ball milling - Industrial applications.	1
	3	Carbon Nanotubes and Fullerenes - Structure, properties and unique characteristics of CNTs and fullerenes - Synthesis methods and applications of CNTs and fullerenes in various fields, such as electronics, materials science, and medicine	1
	4	Properties of Nanoparticles - Overview of the properties of nanoparticles - Optical properties: examples of nanoparticles exhibiting optical phenomena (e.g., plasmonic nanoparticles) - Magnetic properties: discussion on magnetic nanoparticles and their applications in magnetic resonance imaging (MRI) and drug delivery - Mechanical, thermal, and catalytic properties of nanoparticles with relevant examples	2
	5	Applications of Nano Materials	1

		- Nano Sensors and its Applications in healthcare, environmental monitoring, security etc - Quantum dots, its optical and electronic properties. Applications in Solar Cells, Biomedical Imaging. - Introduction to Surface Plasmon Resonance	
IV	**PRINCIPLES OF QUALITATIVE ANALYSIS**		**6**
	1	Introduction to Qualitative Analysis: Definition and significance of qualitative analysis in chemistry. Basic principles of qualitative analysis: separation, detection, and identification of ions or compounds. Overview of the qualitative analysis process: systematic approach and testing schemes. Importance of qualitative analysis in research, industry, and environmental monitoring.	1
	2	Solubility Equilibria in Qualitative Analysis: Solubility product (Ksp) and its importance in qualitative analysis Predicting solubility of salts and formation of precipitates. Common ion effect and its impact on solubility equilibria. Selective precipitation and separation of ions based on solubility rules	2
	3	Identification of Cations in Qualitative Analysis: Systematic analysis of cations: principles, procedures and chemistry Identification of Group I cations: Ag^{+}, Hg_2^{2+}, and Pb^{2+} ions Identification of Group II cations: Cu^{2+}, Bi^{3+}, and Cd^{2+} ions Identification of Group III cations: Fe^{3+}, Al^{3+}, and Cr^{3+} ions	1
	4	Identification of Anions in Qualitative Analysis: Systematic analysis of anions: principles, procedures and chemistry Identification of Group I anions: Cl^{-}, Br^{-}, and I^{-} ions Identification of Group II anions: S^{2-}, SO_3^{2-}, and CO_3^{2-} ions Identification of Group III anions: PO_4^{3-}, NO_3^{-}, and CH_3COO^{-} ions	1
	5	Applications of Qualitative Analysis: Real-world applications of qualitative analysis in various industries and fields. Case studies highlighting the importance of qualitative analysis in forensic science, environmental monitoring, and pharmaceuticals. Future trends and advancements in qualitative analysis techniques.	1
V	**PRACTICALS: INORGANIC QUALITATIVE ANALYSIS**		**60**
	I	**Qualitative Inorganic Analysis (Micro Analysis)**	**42**
	1	Studies of the reactions of the following basic radicals with a view to their identification and confirmation: Lead, Copper, Bismuth, Cadmium, Tin, Antimony, Ferrous, Ferric ions, Aluminium, Chromium, Zinc, Manganese, Cobalt, Nickel, Calcium, Strontium, Barium, Magnesium, Potassium and Ammonium ions/radicals	10
	2	Studies of the reactions of the following acid radicals with a view to their identification and confirmation:	10

		Carbonate, Sulphide, Nitrite, Nitrate, Fluoride, Chloride, Bromide, Iodide, Borate, Acetate, Oxalate, Chromate, Phosphate and Sulphate anions.	
	3	Systematic qualitative analysis by microscale methods of salt mixtures containing two acidic and two basic radicals from the above list (more than one interfering radical should be avoided). **(Minimum 10 mixtures are to be analysed)**	22
	II	**Inorganic Preparations (Open ended – Minimum 4 preparations)** Preparations of 1. Potash alum 2. Hexamine cobalt Chloride 3. Tetramine copper Sulphate 4. Mohr's salt 5. Microcosmic salt 6. Sodium cobalt nitrate 7. Sodium nitroprusside 8. vii) Manganese phthalocyanin 9. Potassium trioxalatochromate 10. Potassium trioxalatoferrate	**18**

References:

1. B.R. Puri L.R. Sharma, K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.
3. R. Gopalan, V.Ramalingam, *Concise Coordination Chemistry*, 1st Edn.,Vikas Publishing House, New Delhi, 2001.
4. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, 5th Edn., Vol. I, S Chand, 2012.
5. S. Manku, *Theoretical Principles of Inorganic Chemistry*. McGraw-Hill Education; New edition (1 August 1982)
6. M.C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.
7. J. E. Huheey, E.A. Keitler, R. L. Keitler, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi,2013.
8. B.K. Sharma, *Industrial chemistry*, 11th Edn., Goel publishing House, Meerut, 2000.
9. M.N. Greenwood, A. Earnshaw, *Chemistry of elements*, 2nd Edn., Butterworth,1997.
10. J V. V.Ramanujam, "*Semi micro Qualitative Analysis*"
11. E. S. Gilreath "*Qualitative Analysis using semi micro method*" Mc Graw Hill.
12. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.

Further Reading

1. James E. House, Inorganic Chemistry, academic press, 2008.
2. W.U. Malik, G.D.Tuli, R.D. Madan, selected Topics in Inorganic Chemistry, S. Chand and Co., New Delhi, 2010.
3. F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., Wiley India Pvt. Ltd., New Delhi,2009.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain an understanding of various materials such as glasses, boron compounds, phosphorus oxides, refractory materials, halogen compounds, noble gases, and inorganic polymers.	R, U	PSO-1,2,5
CO-2	Equip with the knowledge and skills to analyze nuclear phenomena and evaluate the benefits and drawbacks of nuclear technology in various fields.	U, An	PSO-1,2,5
CO-3	Gain a comprehensive understanding of the historical development of nanoscience and nanotechnology, including key milestones and discoveries.	R, U	PSO-1,2
CO-4	Enhance their problem-solving and critical thinking skills by analyzing and comparing various methods for synthesizing nanoparticles across various fields.	An, Ap	PSO-1,2,3,5
CO-5	Enhance problem-solving skills by providing practical insights into qualitative analysis applications in various industries.	An, Ap	PSO-1,2,3,5
CO-6	Proficiency in qualitative inorganic analysis techniques, enabling to accurately identify cations and anions in complex mixtures.	Ap, E	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INORGANIC CHEMISTRY II

Credits: 2:0:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,5	R, U	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,5	U, An	C, P	L	-
3	CO-3	PO-1,6 PSO-1,2	R, U	F, C	L	-
4	CO-4	PO-1,2,3,6 PSO-1,2,3,5	An, Ap	C, M	L	-
5	CO-5	PO-1,2,3,6 PSO-1,2,3,5	An, Ap	C, M	L	-
6	CO-6	PO-1,3,6 PSO-1,2,3	Ap, E	P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	-	-	2	1	-	-	-	-	2	-	-
CO 2	3	2	-	-	2	1	2	-	-	-	2	-	-
CO 3	2	1	-	-	-	1	-	-	-	-	2	-	-
CO 4	3	3	2	-	2	2	2	2	-	-	2	-	-
CO 5	3	2	3	-	2	1	2	1	-	-	2	-	-
CO 6	1	2	2	2	-	2		2	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓
CO 6	✓		✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSCCHE201**				
Course Title	**ANALYTICAL PRINCIPLES I**				
Type of Course	**DSC**				
Semester	4				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	4 hours	6
Pre-requisites	1. Higher secondary level chemistry 2. UK1DSCCHE100				
Course Summary	The course covers significant figures, error analysis, and various chromatographic techniques including HPLC, TLC, and paper chromatography, as well as solvent extraction and gravimetric analysis methods. Practical components include inorganic qualitative analysis and gravimetric analysis techniques, providing students with hands-on experience in analytical chemistry methods and preparing them for accurate and precise chemical analysis in research and industry settings.				

Detailed Syllabus:

Module	Unit	Content **ANALYTICAL PRINCIPLES I**	Hrs **90**
I	**SIGNIFICANT FIGURES & ERRORS IN CHEMICAL ANALYSIS**		**6**
	1	Significant figures and Reporting Data, Rules of Computing.	2
	2	Accuracy & Precision, Classification of errors: Determinate & Indeterminate Errors, Detection & Minimisation of errors, Propagation of Indeterminate Error	4
II	**CHROMATOGRAPHY**		**9**
		Overview of Analytical Separation, Classification of Chromatographic Methods, General description of chromatography, Principles of chromatographic separations, Classification of chromatography: Adsorption, Partition, Ion exchange and Size exclusion chromatography	2
		General Theory of Column Chromatography, Theory of Column Efficiency in Chromatography, Chromatographic Resolution, Capacity Factor, Column Selectivity, Column Efficiency, Optimizing Chromatographic Separations	2
		High-Performance Liquid Chromatography, Stationary Phases in HPLC, Chiral Stationary Phases, Equipment for HPLC, Detectors	2

		Thin-layer chromatography (TLC), R_f values, TLC stationary phases, TLC mobile phases, TLC sample application, HP TLC development, development tanks, HPTLC gradient elution, HPTLC, spot visualization,	2
		Paper chromatography: principle, papers as a chromatographic medium, modified papers, solvent systems, mechanism of paper chromatography, different development methods-ascending, descending, horizontal, circular spreading	1
III	**QUALITATIVE ANALYSIS & SOLVENT EXTRACTION**		**9**
		Inorganic qualitative analysis – systematic approach and testing schemes. Importance of qualitative analysis in research, industry, and environmental monitoring. Need for elimination of interfering acid radicals and their elimination methods – oxalate, fluoride, borate, phosphate, chromate, arsenite and arsenate. Common ion effect, solubility product and their application in qualitative analysis.	3
		Solvent Extraction: Principles, Advantages, Separation factor/ Efficiency, Multiple Extraction, Factors Affecting Solvent Extraction, Counter current distribution principle (Craig counter current extraction, Solvent Extraction Methods: Chelate extraction, Extraction by solvation, Ion pair formation, Synergic extraction	4
		Techniques of Solvent Extraction: Batch, Continuous & Counter current Extraction, Applications of Solvent Extraction	2
IV	**GRAVIMETRIC ANALYSIS**		**6**
		Introduction to gravimetric analysis, Types: Precipitation, Volatilization and Particulate Gravimetry Precipitation methods, the colloidal state, Supersaturation and precipitate formation, Factors influencing precipitation, Co-precipitation & post-precipitation Conditions of precipitation, Precipitation from homogeneous solution,	4
		Ageing and filtration of precipitate, filter papers, Gooch crucible, Sintered glass crucible, Washing, drying and ignition of precipitates.	1
		Advantages of organic reagents over inorganic reagents, reagents used in gravimetry (8-hydroxy quinoline (oxine) and dimethyl glyoxime (DMG)	1
V	**PRACTICALS: INORGANIC QUALITATIVE ANALYSIS &**		**60**
	I	**Qualitative Inorganic Analysis (Micro Analysis)**	**42**
	1	Studies of the reactions of the following basic radicals with a view to their identification and confirmation: Lead, Copper, Bismuth, Cadmium, Tin, Antimony, Ferrous, Ferric ions, Aluminium, Chromium, Zinc, Manganese, Cobalt, Nickel, Calcium, Strontium, Barium, Magnesium, Potassium and Ammonium ions/radicals	10
	2	Studies of the reactions of the following acid radicals with a view to their identification and confirmation: Carbonate, Sulphide, Nitrite, Nitrate, Fluoride, Chloride, Bromide, Iodide, Borate, Acetate, Oxalate, Chromate, Phosphate and Sulphate anions.	10

	3	Systematic qualitative analysis by microscale methods of salt mixtures containing two acidic and two basic radicals from the above list (more than one interfering radical should be avoided). **(Minimum 10 mixtures are to be analysed)**	22
	II	**Inorganic Preparations (Open ended – Minimum 4 preparations)** Preparations of 11. Potash alum 12. Hexamine cobalt Chloride 13. Tetramine copper Sulphate 14. Mohr's salt 15. Microcosmic salt 16. Sodium cobalt nitrate 17. Sodium nitroprusside 18. vii) Manganese phthalocyanin 19. Potassium trioxalatochromate 20. Potassium trioxalatoferrate	**18**

References

1. Vogel, *A Text Book of Quantitative Inorganic Analysis*, Longman, 5th edition, 1989.
2. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.
3. J. Holme and H. Perk, *Analytical Biochemistry*, 3rd edition, Prentice Hall, 1998.
4. K. Sharma, *Analytical Chemistry by PDF*, Krishna Prakashan Media(P) Ltd., 2nd Edition, 2006
5. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
6. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.
7. V.V.Ramanujam, "*Semi micro Qualitative Analysis*"
8. E.S.Gilreath "*Qualitative Analysis using semi micro method*" Mc Graw Hill.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain a comprehensive understanding of analytical data that enables accurate collection, analysis, and reporting in scientific endeavors while identifying and resolving potential sources of error.	U, An	PSO-1,2,3
CO-2	Overview of analytical separation techniques, the principles	U, An, Ap	PSO-1,2,3

	and classifications of chromatographic methods including adsorption, partition, ion exchange, and size exclusion chromatography.		
CO-3	Gain knowledge in various chromatographic techniques and equip with the skills to perform chromatographic separations, optimize conditions, and analyze results effectively for diverse analytical applications.	AP, E	PSO-1,2,3,5
CO-4	Explore the principles, techniques, and applications of solvent extraction to understand the fundamentals of extraction processes, optimize extraction conditions, and apply solvent extraction methods effectively.	An, Ap	PSO-1,2,3,5
CO-5	Equip with the skills to perform precise quantitative analysis through gravimetric methods in analytical chemistry practice.	U, An	PSO-1,2,3
CO-6	Develop proficiency in identifying ions and compounds in solution, enhancing analytical skills for qualitative chemical analysis.	U, An	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL PRINCIPLES I

Credits: 2:0:2 (Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO- 1,6 PSO-1,2,3	U, An	F, C	L	-
2	CO-2	PO- 1,3,6 PSO-1,2,3	U, An, Ap	C, P	L	-
3	CO-3	PO- 1,2,3,6 PSO-1,2,3,5	AP, E	P, M	L	-
4	CO-4	PO- 1,2,6 PSO-1,2,3,5	An, Ap	P, M	L	-
5	CO-5	PO- 1,2,6 PSO-1,2,3	U, An	F, C	-	P

6	CO-6	PO- 1,6 PSO-1,2,3	U, An	F, C	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 2	3	2	3	-	-	1	-	1	-	-	2	-	-
CO 3	3	3	3	-	2	1	1	1	-	-	2	-	-
CO 4	2	3	2	-	2	1	2	-	-	-	2	-	-
CO 5	2	3	3	-	-	1	1	-	-	-	2	-	-
CO 6	2	3	3	-	-	2	-	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓	✓	✓	✓
CO 5	✓			✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSCCHE202**				
Course Title	**ORGANIC CHEMISTRY II**				
Type of Course	**DSC**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Higer secondary level chemistry 2. UK2DSCCHE100				
Course Summary	The course covers aromaticity for understanding the reactivity and stability of benzene and its derivatives. Organic reaction mechanisms delve into nucleophilic and electrophilic substitutions, eliminations, and rearrangements, providing insights into the behaviour of organic compounds. Practical applications in quantitative analysis and organic preparations enhance understanding and application of theoretical concepts in real-world scenarios.				

Detailed Syllabus:

Module	Unit	Content ORGANIC CHEMISTRY II	Theory 75 Hrs
I	**ARENES AND AROMATICITY**		**12**
	1	Concept of aromaticity- Heat of hydrogenation and Heat of combustion of benzene-Electron delocalization and resonance-Representation of Benzene and Benzene derivatives-Nomenclature of Aromatic Compounds	2
	2	Huckel's rule-Types of aromaticity- aromatic, anti-aromatic, non-aromatic Frost circle diagram for cyclobutadiene and benzene Aromaticity in benzenoid and non-benzenoid compounds and charged rings, annulenes, fulvenes, azulenes.	2
	3	Mechanism of aromatic electrophilic substitution – energy profile diagram- nitration sulphonation, halogenation, Friedel Craft's alkylation and acylation.	3
	4	Directive influence of functional group in mono-substituted benzene with ring activating and deactivating groups (-OH, -NH_2, NO_2, -CH_3, -CHO, COOH and halogens), Directive influence in disubstituted benzene o-cresol, m-cholro nitrobenzene, p-bromotoluene	4

	5	Carcinogenicity and toxicity of aromatic hydrocarbons	1
II	**ORGANIC REACTION MECHANISM II**		**12**
	6	Aliphatic nucleophilic substitutions: properties of nucleophiles, leaving groups, solvents, mechanism of SN1, SN2 and SNi reactions, energy profile diagram for SN^1 and SN^2 reactions, Effect of ~~nature of~~ leaving group, substrate, solvent and nucleophile/nucleophilicity and basicity in substitution reactions, Stereochemistry of SN reactions, Walden Inversion.	3
	7	Neighbouring group participation (anchimeric assistance): examples involving acetoxonium and phenonium ions, participation of lone pair of electrons in substitution reaction	3
	8	Aromatic nucleophilic substitution – Uni and bimolecular displacement mechanism, Addition elimination (SNAr) and ArSN1 reactions	3
	9	Elimination – addition (Benzyne) mechanism with evidence, regiochemistry of addition of nucleophiles to substituted benzynes	3
III	**ORGANIC REACTION MECHANISM III**		**12**
	10	Elimination reaction: 1,1 and 1,2 eliminations, mechanisms of E1, E1CB and E2 reactions, Regioselectivity in elimination reactions (Hoffmann and Saytzeff rule and Bredt's rule). Stereochemistry of E1, and E2 reactions.	3
	11	Substitution vs Elimination	1
	12	Electrophilic addition to carbon-carbon double bonds: mechanism of addition of bromine, hydrogen, H_2O, oxymercuration, and hydroboration (followed by oxidation only), regioselectivity in addition reactions (Markownikoff's rule and peroxide effect), stereo aspects, effect of substituents on the rate of additions, cis and trans hydroxylation of alkenes and cycloalkenes.	2
	14	Molecular rearrangement reactions- General mechanistic considerations – nucleophilic rearrangement, electrophilic rearrangement and carbene rearrangement	3
	15	Wagner–Meerwein rearrangement, Schmidt rearrangement and Lossen rearrangement, Stevens rearrangement, Fries rearrangement (with mechanism)	3
IV	**INTRODUCTION TO PHYSICAL ORGANIC CHEMISTRY**		**9**
	16	Reaction coordinates- difference between transition state and intermediates, Energy profiles	3
	17	Thermodynamic and kinetic control of reaction. The Hammond postulate (qualitative treatment). Primary, secondary and inverse kinetic isotopic effects	3
	18	Methods of determining mechanism, identification of products, detection of intermediates, catalytic study, isotopic labeling, stereochemical evidence, kinetic evidence	3

V	**ORGANIC CHEMISTRY PRACTICAL- Organic Quantitative Analysis, Determination of Physical constants, Preparations and separation techniques**		**30**
		Quantitative Analysis	
	19	a) Estimation of phenol	3
	20	b) Estimation of Aniline	3
	21	c) Determination of physical constants; i) Determination of melting point of an organic compound; ii) Determination of boiling point of an organic compound;	3
		Organic Preparations and separations	
	22	a) Halogenation :Bromination of acetanilide	3
	23	b) Nitration of Acetanilide or nitrobenzene	3
	24	c) Oxidation of benzaldehyde/Toluene/Benzyl chloride	2
	25	d) Acetylation of salicylic acid or aniline	2
	26	e) Benzoylation of phenol or aniline	2
		f) Hydrolysis of ethyl acetate and benzamide	2
	27	g) Preparation of Soap (Demonstration only)	2
	28	d) Steam distillation –Extraction of essential oil from citrus fruits/eucalyptus leaves (demonstration only)	2
	29	e) Chromatography (demonstration only): i) TLC of simple organic compounds (using TLC sheets); ii) *Paper chromatographic separation of mixture of inks and sugars; iii) Column chromatographic separation of a mixture of dyes	2
	30	f) Recrystallisation of any five different classes of organic compounds	1

References

For Theory

Text books:

1. A.Bahl and B.S.Bahl, Advanced Organic Chemistry, S.Chand & Company, New Delhi.
2. L.G.Wade Jr, Organic Chemistry, Pearson Education, New Delhi.
3. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, A textbook of Organic Chemisty, Vikas Publishing House (Pvt) Ltd., New Delhi..
4. S.C.Sharma and M.K.Jain, Modern Organic Chemistry, Vishal Publishing Company, New Delhi.
5. D.Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, New Age International Publizhers, New Delhi.
6. J.Clayden, N.Greeves and S.Warren, Organic Chemistry, Oxford University Press, New York.
7. I L Finar, “Organic Chemistry” Vol – 1, 5th Edition, Pearson Education, NewDelhi

8. Physical Organic Chemistry, Neil Isaacs, 2nd Edition PHI, ELBS

For Further Reading

1. P.S.Kalsi, Organic Reactions, Stereochemistry, and Mechanism, New Age International Publishers, New Delhi
2. R.T.Morrison, R.N.Boyd. Organic Chemistry, Pearson Education, New Delhi.
3. P.Y.Bruice, Essential Organic Chemisty, Pearson Education, New Delhi.
4. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, Pearson Education, New Delhi.
5. G.M. Louden, Organic Chemistry, Oxford University Press, New York.
6. E.L.Eliel, Stereochemistry of Carbon compounds, Tata McGraw Hill Publishing House, New Delhi.
7. J.March, Advanced Organic Chemistry, John Wiley & Sons., NY.
8. S.M.Mukerji and S.P.Singh, Reaction Mechanism in Organic Chemistry, McMillan Publishers.
9. R.O.C. Norman and J.M.Coxon, Principles of Organic Synthesis, CRC Press.

For Practicals

Textbooks

1. A.I.Vogel, “A text book of Qualitative Analysis including semi micro methods” Longmans.
2. V.V.Ramanujam, “Semi micro Qualitative Analysis”
3. E.S.Gilreath “Qualitative Analysis using semi micro method” Mc Graw Hill
4. A.I.Vogel, “A text book of Qualitative Inorganic Analysis” Longmans
5. A.I.Vogel, “Elementary Practical Organic Chemistry” Longmans
6. J B Yadav,Advanced Practical Physical Chemistry, Goel ,Publishing House

For Further Reading

1. Day and Raman, “Laboratory Manual of Organic Chemistry”.
2. B.Viswanathan and P.S Raghavan , “Practical Physical Chemistry” 2005 Edn. Viva Books (Pvt.Ltd)
3. F.G Mann and B.C Saunders, “Practical Organic Chemistry” 4th Edn, Orient Longmann
4. A.Findlay, “Practical Physical Chemistry” Creative Media
5. R.C.Das and E.Behara, “Experimental Physical Chemistry”, Tata Mc Graw Hill
6. N.K.,Vishnu, “Advanced practical organic chemistry” Vikas publishing house, New Delhi

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concept of aromaticity, orientation effects in aromatic systems and toxicity of aromatic hydrocarbons	U	PSO-1,2,3,4

CO-2	Identify aliphatic and aromatic nucleophilic substitution, elimination reactions and effects of NGP.	R, U	PSO-1,2
CO-3	Predict favourable reaction pathways for substitution/elimination reactions and identify rearrangement reactions.	U,An	PSO-1,2
CO-4	Identify various aspects of thermodynamic and kinetic control of reactions and various methods of determination of reaction mechanism.	Ap, An	PSO-1,2
CO-5	Practice systematic scientific procedure for quantitative analysis, preparation and separation methods of organic compounds.	U, Ap, C	PSO-1,2,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ORGANIC CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,2,3,4	U	F	L	-
2	CO-2	PSO-1,2	R, U	F	L	-
3	CO-3	PSO-1,2	U,An	C	L	-
4	CO-4	PSO-1,2	Ap, An	F,C	L	-
5	CO-5	PSO-1,2,4,5	U, Ap, C	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	1	2	3	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	2	2	-	-	-	-	-	-
CO 3	3	2	-	-	-	2	2	-	-	-	-	-	-
CO 4	2	3	-	-	-	2	2	-	-	-	-	-	-
CO 5	2	2	-	3	3	2	2	3	-	-	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5	✓	✓	✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSCCHE203**				
Course Title	**CONCEPTS OF POLYMER CHEMISTRY**				
Type of Course	**DSC**				
Semester	4				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	Higher secondary level chemistry				
Course Summary	➢ To know the concept of polymerization and types of polymers ➢ To understand the characteristics of polymers ➢ To acquire knowledge about the polymerization techniques and polymer processing ➢ To know the chemistry of individual polymers ➢ To have an idea about the recent advances in polymer sciences				

Detailed Syllabus:

Module	Unit	Content CONCEPTS OF POLYMER CHEMISTRY	Hrs 75
I	**INTRODUCTION TO POLYMERS**		**9**
	1	Definition - Monomer, polymer and polymerization - classification of polymers on the basis of (i) origin - Natural, semi synthetic, synthetic, (ii) Physical properties and applications- Rubbers, plastic, fibers (iii) Thermal response - thermoplastics, thermosetting	3
	2	(iv) Structure- Homopolymers (linear, branched, cross link or network), Copolymers (Random, Alternate, Block, Graft)	2
	3	(v) Crystallinity - non-crystalline (amorphous), semi-crystalline (vi) Mode of formation - Addition, Condensation Polymerization (definition and examples only)	2
	4	(vii) Methods of polymerization - Bulk, Solution, Suspension Polymerization (definition and examples only)	2
II	**CHARACTERISTICS OF POLYMERS**		**9**
	5	Glass transition temperature (Tg) - definition – Factors affecting Tg – relationships between Tg and molecular weight and melting point. Significance of Tg and Tm. Introduction to DTA and DSC as thermal characteristics.	3

	6	Molecular weight of polymers. Number average, weight average, sedimentation and viscosity average molecular weights. Degree of polymerization- polydispersity index.	3
	7	Polymer degradation - basic idea of thermal, photo and oxidative degradation of polymers - mechanistic pathways, Autooxidation, effect of environmental factors.	3
III	**POLYMERIZATION TECHNIQUES AND PROCESSING**		**9**
	8	Bulk, solution, suspension, emulsion and melt condensation polymerizations.	4
	9	Polymer processing - calendaring - die-casting, rotational casting-compression moulding - injection moulding - blow moulding - extrusion moulding and reinforcing.	5
IV	**CHEMISTRY OF SOME COMMERCIAL POLYMERS ADVANCES IN POLYMERS**		**18**
	10	Preparation, properties and uses of the following polymers- Thermoplastics: polyethylene, polypropylene, polystyrene, polyacrylonitrile, polyvinyl chloride, nylon, polyester.	3
	11	Thermosetting: Phenol formaldehyde resin, urea formaldehyde resin, melamine formaldehyde, epoxy resin, polycarbonate.	3
	12	Elastomers: Natural rubber and synthetic rubber, Styrene and neoprene rubber. Vulcanization of natural rubber, Buna -N, Buna-S	3
	13	Biodegradable polymers (Basic idea only). Biomedical polymers - contact lens, dental polymers, artificial heart, kidney, skin and blood cells.	3
	14	High temperature and fire-resistant polymers-silicones-polyphosphazenes.	3
	15	Conducting polymers: Polysulphur nitrile, polyphenylene, polypyrrole and polyacetylene, polyaniline.	3
V	**PRACTICALS: POLYMER CHEMISTRY EXPERIMENTS**		**30**
	16	**A. Determinations of Physical properties of polymers**	5
		Solubility, density, softening and melting behaviour	
	17	**B. Analysis of polymers**	15
		Preliminary investigation	
		Elemental analysis	
		Classification of polymers	
		Identification tests	
	18	**C. Preparation of polymers**	10
		Preparation of polystyrene	
		Preparation of Polyaniline	
		Preparation of phenol-formaldehyde resin	

References:

1. V.R. Gowarikar, N. V. Viswanathan and J. Sreedhar. *Polymer Science*, Wiley Eastern, 1995.

2. F.W. Billmeyer, *Text Book of Polymer Science*, 3rd edition, John Wiley and sons, New York, 2002.
3. R. J. Young & P. A. Lovell, *Introduction to polymers,* Chapman & Hall, London. Second edition. Wiley online library 1991.
4. G.S. Mishra, *Introduction to polymer chemistry,* Wiley Eastern Ltd., New Delhi.
5. Wayne. R. Sorenson, Fred Sweeny, Tod. W. Campbell. *Preparation methods of polymer chemistry* - John Wiley & son, INC., Publication. 2001.
6. K.J.Saunders, *Organic Polymer Chemistry,* 2nd Edition, Chapman & Hall.1973, Newage publishers 1993.
7. *Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry*, University of Mumbai.
8. Dr. Kuruvilla Joseph, Dr. G. D. Gem Mathew- *Advanced practical polymer chemistry*- polymer publication, 2001.
9. D.G. Hundiwale, V.D. Athawale, U. R. Kapadi, V.V. Gite., *Experimental in polymer science* - New age International (P) Limited, Publishers 2009.
10. Wayne R. Sorenson, Tod W. Campbell. *Preparative method in polymer science.*
11. J. Urbanski W. Czerwinski, K. Janicka, F. Majewska & H. Zowall, *Analysis of synthesis polymer & plastics*- Ellis Horwood limited- 1st edition 1977.
12. J. Urbanski. *Handbook of Analysis of Synthetic Polymers and Plastics*- 1977, Ellis Horwood Ltd, publisher.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamental principles and characteristics of polymers, including their structure, properties, and applications in various industries.	R, U	PSO-1,2,3
CO-2	Gain insight into different polymerization techniques and processing methods, enabling students to analyse and select appropriate methods for specific polymer synthesis and production requirements.	U, An	PSO-1,2,3,4
CO-3	Acquire knowledge of the chemistry behind commonly used commercial polymers, such as polyethylene, polypropylene, PVC, polystyrene, and others, allowing students to comprehend their synthesis pathways and structure-property relationships.	U, An	PSO-1,2,3,4
CO-4	Explore advances in polymer science and engineering, including emerging materials, novel synthesis methods, and innovative applications, fostering an	An, Ap	PSO-1,2,3,4,5

	understanding of the latest developments and trends in the field.		
CO-5	Develop critical thinking and problem-solving skills necessary for evaluating and designing polymer-based materials and processes, preparing students for careers in research, development, and industrial applications within the polymer industry.	Ap, E	PSO-1,2,3,4,5
CO-6	Proficiency in the experimental determination of physical properties, analysis and preparation of polymers.	U, Ap	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CONCEPTS OF POLYMER CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3,4	U, An	F, C	L	-
3	CO-3	PO-1,2,3,6 PSO-1,2,3,4	U, An	F, C	L	-
4	CO-4	PO-1,2,3,6 PSO-1,2,3,4,5	An, Ap	C, P	L	-
5	CO-5	PO-1,2,3,6 PSO-1,2,3,4,5	Ap, E	P, M	L	-
6	CO-6	PO-1,6 PSO-1,2,3	U, Ap	C, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	1	-	-	-	-	2	-	-
CO 2	2	3	3	2	-	2	1	-	-	-	2	-	-
CO 3	2	3	2	2	-	1	2	1	-	-	2	-	-
CO 4	2	3	3	2	2	2	2	2	-	-	2	-	-
CO 5	2	3	3	2	2	2	1	2	-	-	2	-	-
CO 6	3	3	2	-	-	1	-	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓
CO 6	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE200**				
Course Title	**ENVIRONMENTAL CHEMISTRY II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3hours	-	2	5
Pre-requisites	1. Fundamental concept of Aquatic chemistry 2. General chemistry 3. UK3DSECHE200				
Course Summary	This course provides students with the knowledge of the chemical processes and interactions that occur in natural waters, including oceans, rivers, lakes, and groundwater. This course also describes about water pollution and its consequences. This course also highlights the methods of determining water quality parameters and treatment of waste water				

Detailed Syllabus:

Module	Unit	Content ENVIRONMENTAL CHEMISTRY II	Hrs 75
I	**INTRODUCTION TO AQUATIC CHEMISTRY**		**9**
	1.1	Aquatic Chemistry: Introduction, structure and physico-chemical properties of water	1
	1.2	Composition of water bodies-ocean, lakes, streams, rivers and wetlands,	2
	1.3	Acid-base reaction, redox reactions in water.	1
	1.4	Colloidal materials in water. Chemical speciation, Biomagnification	2
	1.5	Aquatic biochemical process- Microbially mediated redox reactions, carbon transformation by bacteria, nitrogen transformation by bacteria, microbial transformation of phosphorus and Sulphur	3
II	**WATER POLLUTION**		**9**
	2.1	Introduction, water pollutants-types, sources.	2
	2.2	Eutrophication- causes, effects and control, trace elements in water	1
	2.3	Organic matter in water- origin and environmental issues. Inorganic pollutants- acid mine drainage, heavy metals (Hg, Pb, As,Cd).	2
	2.4	Sediments, radioactive materials. Soaps and detergents- Environmental impacts of water pollution.	2
	2.5	Health effects of water pollution	2

III	**WATER QUALITY ANALYSIS**		**18**
	3.1	Objectives of water analysis, Chemical substances affecting potability (Basic concepts and determination)- colour by platinum cobalt method & colorimetric method, odour, turbidity by Jackson Candle Turbidimeter & nephelometer, conductivity - electrical conductivity, pH by electrometric method.	4
	3.2	Acidity and Alkalinity by Titrimetric method, Chloride by Mohr's method, Total Solid - suspended solids & dissolved solids and Hardness by complexometric method. Hardness of water- types of hardness and removal.	4
	3.3	Chemical substances affecting health (Basic Concepts and Determination) - Ammonia by Spectrophotometric Nessler's Method, Sulphate by Volumetric Method, Sulphide, Phosphate by Spectrophotometric Method, Fluoride by Spadns Method.	6
	3.4	Chemical substances indicative of pollution (Basic Concepts and Determination) – Dissolved Oxygen by Modified Winkler Method, COD, BOD, Total Organic Carbon by TOC Analyser	4
IV	**WASTE WATER TREATMENT**		**9**
	4.1	Criteria of water purity. Waste water treatment methods- Conventional water treatment methods- aeration, settling or sedimentation, coagulation, filtration and disinfection	4
	4.2	Advanced waste water treatment methods: reverse osmosis, electrodialysis, nutrient removal	4
	4.3	Water conservation- concept and significance	1
V	**WATER QUALITY ANALYSIS PRACTICALS I**		**30**
	1	Preliminary examination of different water samples (Colour, Odour, Temperature, Turbidity, p^H) – Minimum 5 samples	
	2	Determination of conductivity of water – Using conductivity meter – minimum 3 samples	
	3	Percentage of chlorine available in bleaching powder – Minimum 3 samples	
	4	Measurement of chloride, sulphate and salinity of water sample by simple titration method ($AgNO_3$ and potassium chromate)- Minimum 3 samples	
	5	Determination of DO, BOD and COD-Minimum 3 samples	

References

1. Balram Pani, *Text Book of Environmental Chemistry*, I.K International Publishing House Pvt Ltd
2. A.K De, *Environmental Chemistry* Seventh Edition, New Age International Publishers
3. Gray W. vanLoon & Stephen J. Duffy, *Environmental Chemistry: A Global Perspective*, Oxford University Press
4. H. Kaur, *Environmental Chemistry*, Pragati Prakashan
5. V.K Ahluwalia, *Environmental Chemistry*, Second Edition, Ane Books Pvt. Ltd.

6. Ronald A. Bailey, Herbert M. Clark, James P. Ferris, Sonja Krause, Robert L. Strong, *Chemistry of the Environment*, Second Edition, Academic Press
7. Asim K. Das, *Environmental Chemistry with Green Chemistry*, Books and Allied (P) Ltd.
8. G S Sodhi, *Fundamentals Environmental Chemistry*, Second Edition, Narosa Publishing House.
9. S.M. Khopkar, *Environmental Pollution Analysis*, Wiley Eastern Ltd, New Delhi
10. S.S. Dara, *A Textbook of Engineering Chemistry*, S.Chand & Company Ltd. New Delhi

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Able to describe the chemical composition and physico-chemical properties of water	U	1,3
CO2	Describe the main sources of water pollution, the main types of pollutant and their environmental impacts	U, R	1,3
CO3	Describe the types of hardness of water; disadvantages and the methods for their removal	U, Ap	1,3
CO4	Understand the appropriate methods and principle behind the practical protocols	Ap	1,2,3,4
CO5	Outline how sewage may be treated before discharge to the environment and realise the importance of water conservation	U	1,3
CO6	Comprehensive understanding of fundamental principles and analytical methods essential for evaluating the quality of water.	U, A	1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	CO1	1,3	U	C	L	
2	CO2	1,3	U, R	F, C	L	
3	CO3	1,3	U, Ap	C	L	
4	CO4	1,2,3,4	Ap	F, C	L	
5	CO5	1,3	U	F, C	L	

6	CO6	1,2,3,4,5	U, A	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

No:	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 2	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 3	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 4	1	2	1	1	-	1	1	-	-	-	-	-	-
CO 5	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 6	1	2	1	1	1	1	1	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓			✓
CO 5	✓			✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE201**				
Course Title	**CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	2 hours	5
Pre-requisites	1. A strong understanding of fundamental chemistry principles is essential. 2. A solid grounding in environmental science provides the context necessary to understand the interconnectedness of environmental chemistry with broader environmental issues and to effectively design and implement pollution control strategies. 3. UK3DSECHE201				
Course Summary	• This course provides a comprehensive understanding of environmental chemistry, pollution control, electronics, solar energy, and green chemistry principles for clean energy applications. • Students will engage in hands-on lab sessions to apply theoretical knowledge in water quality analysis and environmental monitoring practices.				

Detailed Syllabus:

Module	Unit	Content **CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- II**	Hrs 75
I	**FUNDAMENTAL ASPECTS OF ENVIRONMENTAL CHEMISTRY**		**9**
	1.1	Environmental chemistry; Definition, principles, and scope of environmental science involve interdisciplinary analysis	1
	1.2	Chemical species and particulars present in the environment, Pollutants., Human-Environment and inter-dependence of human activity meteorology and air pollution. Classification of air pollutants and their effect.	2
	1.3	Water pollution, classification of pollutants, methods and equipment used in wastewater management.	2
	1.4	Introduction to Wastewater Treatment Sampling methodology, Sampling instruments, Sample conservation, Physicochemical and microbial analysis of water	2
	1.5	Chemical & Biological Properties of water – Chemical: pH, TDS, Cations/ Anions, Hardness, Salinity, Alkalinity. Biological properties – DO, BOD, COD, and Bacterial count	2

II	**CONTROL OF POLLUTION AND MANAGEMENT**		**9**
	2.1	Air and water quality standards, Environmental education/awareness, lifestyle changes and consumerism. Values and ethics	1
	2.2	Water purification - Filtration facilities: Homogenization and agglomeration, Flocculation, Jar experimentation; Deionization - calcium carbonate and ion exchange mechanism, Filtration - gradual, swift, and accelerated granular mediums, Sterilization - Chlorination, Ozonisation, and Ultraviolet irradiation applications	2
	2.3	Wastewater management: Urban sewage processing - Fundamental treatment methodologies and schematics, Hazardous waste and treatment technology	2
	2.4	Basics of Data Analysis: Accuracy and precision. Standard deviation, variance and coefficient of variation. Student ‘t’ test, ‘Q’ test, and ‘F’ test. Confidence limits. Errors	2
	2.5	Green Chemistry for Clean Energy Introduction- Goals, Significance of, Basic Components, Functional group approaches to Chemistry Optimisation of Frameworks for the design of greener synthetic pathways Industrial application of green chemistry	2
III	**BASIC ELECTRONICS AND BASIC SOLAR VOLTAICS**		**18**
	3.1	Introduction to Electronics: Concept of electron-Difference between valence and free electrons. Concept of energy bands, Electrical conductivity of materials.	2
	3.2	Properties of semiconductors- Types of Semiconductors- Effect of semiconductors, Formation of p-n junction, Types of biasing.Current flow and characteristics of p-n junction ,Semiconductor Diode , Concept of crystal diode, Zener as a semiconductor diode- Semiconductor Devices - Transistors	3
	3.3	Semiconductor Devices, Transistors,Transistor operation , Opto-Electronic Devices, Working and Characteristics of LED photodiode, working principle and characteristics of solar cells.	3
	3.4	Basics of Photovoltaics – Solar Energy, - Greenhouse effect - Properties of Light - Direct &Diffused radiation - Sun - Terrestrial solar radiation, atmospheric effects	4
	3.5	Semiconductors &Junctions, Semiconductor materials & structure, Intrinsic & Extrinsic, Bandgap, Doping, Absorption of light, Formation of PN junction	**2**
	3.6	Solar cell operation, Structure, solar cell parameters, Resistive effects, Design of solar cells, Optical properties, ARC, Modules & Array, Interconnection of cells.	4
IV	**GREEN CHEMISTRY FOR CLEAN ENERGY**		**9**
	4.1	Introduction- Goals, Significance of, Basic Components, Functional group approaches to Chemistry	3
	4.2	Optimisation of Frameworks for the design of greener synthetic pathways	3
	4.3	Industrial application of green chemistry	3
V	**OPEN ENDED MODULE: PRACTICALS-I**		**30**

	1	Calibration of pH metre, Determination of pH of different solution Determination of Hardness; total hardness, calcium hardness and magnesium hardness of water- EDTA method	
	2	Determination of Physical Parameters: salinity, Electrical conductance and total dissolved salt determination by water quality analyzer	
	3	Alkalinity of water- Titration Method	
	4	Determination of chloride Concentration by Mohrs's method	
	5	Determination of absorption maxima by Spectrophotometric metod	
	6	Water analysis procedures to determine the various toxic metals using AAS; Cu, Fe, Cr, Cd etc.	
	7	Estimation of dissolved oxygen by Winklers method	

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2. *Environmental Chemistry* by Stanley E. Manahan, CRC Press, 2017.
3. *Introduction to Environmental Engineering and Science* by Gilbert M. Masters and Wendell P. Ela, Pearson, 2016.
4. *Principles of Environmental Science and Engineering* by P. Venugopala Rao, Cengage Learning India, 2019.
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7. *Introduction to Green Chemistry* by Albert Matlack, CRC Press, 2010.
8. *Solar Photovoltaics: Fundamentals, Technologies and Applications* by Chetan Singh Solanki, PHI Learning, 2019.
9. *Principles of Semiconductor Devices* by Sima Dimitrijev, Oxford University Press, 2018.
10. *Electronic Devices and Circuit Theory* by Robert L. Boylestad and Louis Nashelsky, Pearson, 2019.
11. *Solid State Electronic Devices* by B. S. Nair, PHI Learning, 2015.
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13. *Environmental Chemistry: A global perspective* by Gary W. vanLoon and Stephen J. Duffy, Oxford University Press, 2019.
14. *Environmental Chemistry* by Colin Baird and Michael Cann, W. H. Freeman, 2019.
15. *Principles of Environmental Chemistry* by James E. Girard, Jones & Bartlett Learning, 2017.
16. *Water Chemistry* by Patrick Brezonik and William Arnold, Oxford University Press, 2011.
17. *Environmental Pollution Control Engineering* by C. S. Rao, Wiley, 2005.
18. *Wastewater Engineering: Treatment and Reuse* by Metcalf & Eddy, McGraw-Hill Education, 2013.
19. *Green Chemistry: Theory and Practice* by Paul T. Anastas and John C. Warner, Oxford University Press, 2000.
20. *Introduction to Photovoltaics* by John R. Balfour, CRC Press, 2019.
21. *Solar Cells: Operating Principles, Technology, and System Applications* by Martin A. Green, Wiley, 2015.
22. *Electronics Fundamentals: Circuits, Devices & Applications* by Thomas L. Floyd and David M. Buchla, Pearson, 2019.

23. *Semiconductor Physics and Devices: Basic Principles* by Donald A. Neamen, McGraw-Hill Education, 2011.
24. *Solid State Electronic Devices* by Ben G. Streetman and Sanjay Banerjee, Pearson.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Demonstrate understanding of chemical and biochemical principles dictating fundamental environmental processes in the atmosphere, hydrosphere, and lithosphere	U	1,3
CO-2	Wastewater management: Urban sewage processing - Fundamental treatment methodologies and schematics, Hazardous waste and treatment technology	R, U	1,3
CO-3	students will demonstrate a thorough understanding of semiconductor physics and its application in electronic devices and solar energy systems, including the principles of semiconductor materials, the operation of semiconductor devices like diodes and transistors, and the design and characteristics of solar cells.	U,A	1,3
CO-4	Outline the fundamental principles of Green Chemistry for Clean Energy	A	1,3
CO-5	Students will develop skills in the analysis of water samples through hands-on laboratory exercises and theoretical understanding of water quality parameters, enabling them to identify and quantify various contaminants and assess water quality levels effectively	A, An,E	1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	F, C	L	

2	CO-2	1,3	R, U	F, C	L	
3	CO-3	1,3	U, A	F, C	L	
4	CO-4	1,3	A	F, C	L	
5	CO-5	1,2,3,5	A, An, E	F, C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	2	-	3	-	-	3	2	-	-	-	-	-	-
CO 2	3	-	2	-	-	2	3	-	-	-	-	-	-
CO 3	3	-	3	-	-	3	2	-	-	-	-	-	-
CO 4	3	-	3	-	-	3	3	-	-	-	-	-	-
CO 5	2	3	2	-	3	3	3	-	-	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE202**				
Course Title	**ANALYTICAL CHEMISTRY- II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2	5
Pre-requisites	1. Basic Chemistry 2. Mathematical Skills 3. Familiarity with laboratory techniques, safety procedures, and basic equipment handling is necessary for conducting experiments and analyses in the course. 4. UK3DSECHE202				
Course Summary	Theoretical concepts & experimental procedures in quantitative analysis, and data analysis techniques				

Detailed Syllabus:

Module	Unit	Content ANALYTICAL CHEMISTRY- II	Hrs 75
I	**ERRORS & THEIR MINIMIZATION IN CHEMICAL ANALYSES**		**9**
	1.1	Limitations of analytical methods, Accuracy & Precision, Classification of errors: Determinate & Indeterminate Errors, Minimisation of errors	4
	1.2	Significant figures, Absolute and relative uncertainty, Propagation of uncertainty	2
	1.3	Rules of Computing, Problems, Ways of expressing accuracy	3
II	**STATISTICAL DATA TREATMENT AND EVALUATION**		**9**
	2.1	Statistical Analysis of Data: Standard Deviation, Confidence Limit, Tests of Significance, Rejection of a Result: *Q* Test, f-test	3
	2.2	Linear Least Squares, Correlation Coefficient and Coefficient of Determination, Detection Limits	2
	2.3	Statistics of Sampling, Distribution of Measurements and Results: Probability Distributions and Confidence Intervals for Populations and samples	4
III	**TITRIMETRIC METHODS OF ANALYSIS**		**18**

	3.1	Titrimetric analysis, Classification of reactions in titrimetric analysis, Standard solutions, Equivalents, normalities and oxidation numbers, Preparation of standard solutions Primary and secondary standards	3
	3.2	Neutralisation Titrations: Neutralisation Indicators, Neutralization curves (a strong acid with a strong base, a weak acid with a strong base, a weak base with a strong acid, a weak acid with a weak base), Choice of indicators in neutralisation reactions	4
	3.3	Redox titrations: Electrode potential, Change of the electrode potential during redox titration, Detection of the endpoint in redox titrations	3
	3.4	Oxidation with $KMnO_4$, $K_2Cr_2O_7$, Cerium (IV) Sulphate, Redox Process involving Iodine	2
	3.5	Complexation Titrations: Introduction, Types of EDTA titrations, Titration of mixtures, selectivity, masking and demasking agents, Metal ion indicators, Standard EDTA solutions, Some practical considerations: pH, concentration of metal ion, amount of indicator, endpoint and colour change	3
	3.6	Precipitation titrations: Precipitation reactions, Determination of endpoints in precipitation reactions.	3
IV	**GRAVIMETRIC ANALYSIS**		**9**
	4.1	Introduction to gravimetric analysis, Precipitation methods, The colloidal state, Supersaturation and precipitate formation, The purity of the precipitate: Co-precipitation	3
	4.2	Conditions of precipitation, Precipitation from homogeneous solution, Washing the precipitate, Ignition of the precipitate	3
	4.3	Quantitative separations based upon precipitation methods: Fractional precipitation, Organic precipitants, Volatilisation or evolution methods	3
V	**ANALYTICAL CHEMISTRY PRACTICAL**		**30**
		PART A **(All experiments in section A are compulsory)**	
	1 2 3	Calibration of Analytical Equipment Cleaning & Sterilization of Glassware Titrimetric estimation of acetic acid content in vinegar.	
		PART B **(Any 5 experiments from B and C need to be done)**	
	1 2	Titrimetric estimation of Ascorbic acid in orange juice, Vitamin C tablets Excel Basics for Statistical Analysis of Laboratory Data	
		PART C	
	1. 2. 3. 4. 5. 6.	Estimation of carbonate and hydroxide present together in mixture. Estimation of carbonate and bicarbonate present together in a mixture. Estimation of free alkali present in different soaps Estimation of Fe(II) using standardized $KMnO_4$ solution.. Estimation of oxalic acid using standardized $KMnO_4$ solution Estimation of Fe(II) with K2Cr2O7 using internal indiator. Estimation of Fe(II) with K2Cr2O7 using external indicator.	

	7.	Iodimetric Titration of Vitamin C	
	8.	Estimation of Magnesium (or Zinc) ions by Complexometry	
	9.	Determination of Total Hardness of Water by Complexometry	

References

1. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Text book of Quantitative Inorganic Analysis*, Longman, Fifth Edition, 1989.
2. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.
3. D. J. Holme and H. Perk, Analytical Biochemistry, 3rd edition, Prentice Hall, 1998.
4. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
5. D. A. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the limitations of analytical methods, classify errors and learn methods for minimizing errors. Apply significant figures, learn rules for computing, and understand absolute and relative uncertainty, as well as propagation of uncertainty.	U, Ap	1,2
CO-2	Analyze statistical data & apply statistical methods for small data sets and detection limits, Understand the concepts of rejection of a result	An, U	1,2
CO-3	Understand theoretical considerations in titrimetric analysis and classification of reactions, gain proficiency in different titrimetric methods	U	1
CO-4	Gain knowledge of gravimetric analysis, precipitation methods, and quantitative separations based on precipitation.	U	1
CO-5	Understand the importance of equipment calibration in analytical chemistry, learn proper cleaning and sterilization techniques for different types of glassware, & get practical skills in computer based statistical anlysis & volumetic titrations	Ap	2,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL CHEMISTRY II

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2	U, Ap	F	L	
2	CO-2	1,2	An, U	F, C	L	
3	CO-3	1	U	F, C	L	
4	CO-4	1	U	C	L	
5	CO-5	PO-6 & 7 PSO2&4	Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	-	-	-	-	2	2	-	-	-	-	-
CO 2	1	3	-	-	-	-	3	3	-	-	-	-	-
CO 3	2	-	-	-	-	-	2	2	-	-	-	-	-
CO 4	2		-	-	-	-	2	-	-	-	-	-	-
CO 5	-	2	-	3	-	-	-	-	-	-	-	**1**	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√	✓	√
CO 4	√		✓	√
CO 5	√			

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE203**				
Course Title	**INDUSTRIAL CHEMISTRY-II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK3DSECHE203				
Course Summary	This course equips students with the theoretical knowledge and practical skills required for the formulation, production, and quality assessment of a wide range of household and personal care products such as soaps, detergents, shampoos etc. emphasizing both traditional and green chemistry approaches.				

Detailed Syllabus:

Module	Unit	Content INDUSTRIAL CHEMISTRY-II	Hrs
I	**SOAPS AND DETERGENTS**		**9**
	1.1	Chemical compositions of soap, Oils and fats, their sources, structure and composition.	1
	1.2	Glycerides and fatty acids, their nomenclature and classification. Soaps and synthetic detergents, raw materials for soaps, General principles of soap making, Manufacture of soaps-Cold, semi boiled and full boiled processes	2
	1.3	Basic concepts of surface-active agents, builders, additives, fillers. perfuming and colouring, Types of soaps, Differences between soaps and detergents	2
	1.4	Various types of detergents, classification of detergents -anionic, cationic, nonionic, amphoterics, biodegradability, Theory of cleansing action of soaps and detergents	2
	1.5	Determination of Total Fatty matter in soap,Saponification value, iodine value and acid value	2
II	**CLEANERS AND DISINFECTANTS**		**9**
	2.1	Introduction, Disinfectant efficacy, Different types of cleaners and disinfectants, natural and synthetic cleaning agents, Qualities of good cleaners, Disinfection and sterilization	2

	2.2	Chemistry of cleaning action and disinfection, Floor, Kitchen, Bathroom and Toilet cleaners, Formulation and manufacture of disinfectants - Hypochlorite (Javel water), Dettol, Pine jelly (giant), Surface disinfectants	3
	2.3	Common disinfectants – Alcohols, Chlorine and its derivatives, Aldehydes. Phenols, Peroxide, Ammonium compounds	2
	2.4	Various types of floor cleaners, Ingredients, Raw material required, Manufacturing process of floor cleaners, Making of herbal and neem floor cleaners	2
III	**HAND SANITIZERS**		**9**
	3.1	Introduction – common sanitization and antiseptic agents, types of sanitizers – chlorine-based sanitizer, quaternary ammonia concentration, Iodine concentration sanitizer and their characteristics	3
	3.2	Uses of hand sanitizer, raw materials - identification, selection of commercially available materials (Turmeric, Sandal, Tulsi, Neem, alcohol etc.), solvent – selection of solvents, solvent purity, viscosity, odour, colour of the solvent, Common solvents used.	3
	3.3	Manufacturing of hand sanitizers, making of natural and synthetic hand sanitizers, herbal hand sanitizers - alovera hand sanitizer, neem hand sanitizer, Antiseptic gel base hand sanitizers	3
IV	**COSMETICS AND SHAMPOOS**		**18**
	4.1	Introduction - Basic concepts, Composition and production of skin care products: Face wash, Moisturizing cream, Cold Cream, Vanishing cream, their relative skin sensory composition	4
	4.2	Sun protection -Classification and production of sunscreen and suntan lotions and SPF, Composition and production of Deodorants, Talcum powder, lipsticks	3
	4.3	Hair care facts, Composition and production of hair care products: Shampoo, Hair conditioners and Hair oils	3
	4.4	Shampoos - Introduction Ingredients, Shampoo formula, Types of Shampoos - Oily hair herbal shampoo, Dry hair herbal shampoos	3
	4.5	Making of - Normal hair/ Dry/Oily hair, Herbal, Dandruff hair, Mint, Charcoal, Pearly and moisturizing milky shampoos	3
	4.6	Evaluation of Shampoos, pH concept and testing for all types of shampoos	2
V		**PRACTICALS** **A minimum of five practicals from the following must be performed and reported**	**30**
		1. Manufacture of bathing soaps. 2. Manufacture of laundry soaps. 3. Making of liquid detergent. 4. Making of bleach. 5. Making of toilet cleaners 6. Making of floor cleaners. 7. Preparation of Hand wash 8. Preparation of sanitiser. 9. Preparation of hair shampoo.	

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1. *Practical Organic Chemistry*, A.I.Vogel
2. Shetty M.C, *Small scale industries and house hold industries in developing economy.*
3. *Vogel's text book of Quantitative Analysis*, Longman ELBS Edition
4. B K Sharma-*Industrial Chemistry*, Goel Publishing House, Meerut.
5. Balsam, S.M., Gershon, S.D, Rieger, M.M, Sagarin, E, and Strianse S.J: *COSMETICS– Science and Technology, 2nd edition*, Vol-2, John Wiley India, New Delhi, 2008.
6. Barel, A.O, Paye, M and Maibach, H.I: *Handbook of Cosmetic Science and Technology*, 3rd Edition, Informa Healthcare, New York.
7. Dr Kuruvilla Joseph, Dr G. D.Gem Mathew, *Advanced practical polymer Chemistry.*
8. O P Vermani, A.K. Narula: *Industrial Chemistry*, Galgotia publications pvt. Ltd, New Delhi.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the chemistry and manufacturing processes of soaps and synthetic detergents.	U	1,2,3
CO-2	Analyse the chemical composition of cleaning agents and cosmetics.	An	1,2
CO-3	Understand the chemical theory behind the efficacy of the cleansing agents and cosmetics	U	1,2
CO-4	Explore the composition and production of hair care products	E	1,2
CO-5	Hands-on experience in manufacturing bathing and laundry soaps, liquid detergent, bleach, toilet and floor cleaners, hand wash, sanitizers, and hair shampoo	E,Ap	1,2,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INDUSTRIAL CHEMISTRY-II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2,3	U	C	L	

2	CO-2	1,2	An	C	T	
3	CO-3	1,2	U	C	L	
4	CO-4	1,2	E	C	T	
5	CO-5	1,2,4	E,Ap	C, M		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	3	2	3	-	-	3	3	-	-	-	-	-	-
CO 2	3	2	-	-	-	1	3	-	-	-	-	-	-
CO 3	3	2	-	-	-	3	3	-	--	-	-	-	-
CO 4	3	2	-	-	-	3	3	-	-	-	-	-	-
CO 5	3	3	-	3	-	3	3	-	-	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓			✓
CO 5	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE204**				
Course Title	**POLYMER CHEMISTRY II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge in polymer chemistry 2. UK3DSECHE204				
Course Summary	The course deals with molecular forces and bonding in polymers, properties of polymers, including molecular weight distribution, kinetics of polymerization, degradation processes, and the unique characteristics of biopolymers and biodegradable polymers. Also there is a module of practicals based on polymer chemistry.				

Detailed Syllabus:

Module	Unit	Content POLYMER CHEMISTRY II	Hrs 75
I	**MOLECULAR FORCES AND BONDING IN POLYMERS**		**9**
	1	Primary structure – polarity of monomers. Secondary structure – conformation and configuration. Tertiary structure – crystalline and amorphous polymers.	3
	2	Polar and non-polar interactions. Segmental mobility and total mobility of polymer chains. Solid, liquid, glassy and rubbery states.	2
	3	Amorphous and crystalline behaviours. Tg and Tm. Viscoelastic deformation. Determination of Tg. Factors influencing Tg (molecular geometry, molecular mass, plasticisers, copolymerization) relationship between Tg and Tm. Importance of Tg. Factors influencing crystalline state, polymer single crystals, spherulites.	4
II	**PROPERTIES OF POLYMERS**		**15**
	1	Molecular weight and molecular weight distribution – number, weight and viscosity average molecular weights of polymers	2
	2	methods of determining molecular weight, practical significance of molecular weight distribution, size of polymers.	2
	3	Introductory concepts of kinetics of polymerization and Carother’s relation.	3

	4	Glassy state, glass transition temperature, TGA, factors affecting GTT, crystallinity in polymers.	2
	5	Viscosity, solubility, optical properties, electrical properties, thermal properties, mechanical properties of polymers	3
	6	Polymer processing- compression moulding, casting, extrusion, fibre spinning, injection moulding, thermoforming, vulcanization of elastomers	3
III	**POLYMER DEGRADATION**		**9**
	1	Process of degradation. Random and chain end degradation.	2
	2	Methods of degradation: thermal degradation – factors affecting thermal stability;	2
	3	mechanical degradation – milling and mastication;	1
	4	photodegradation – photostabilisers	1
	5	oxidative degradation – oxidants and antioxidants;	1
	6	hydrolytic degradation, degradation by high energy radiation, chemical degradation	2
IV	**BIOPOLYMERS AND BIODEGRADABLE POLYMERS**		**12**
	1	DNA and RNA – structure and functions. Structure of proteins,	3
	2	Preparation, properties and applications of cellulose derivatives: cotton and rayon: cellulose plastics: cellulose acetate,cellulose nitrate & regenerated cellulose.	3
	3	Structure and applications of starch, shellac, chitin and chitosan. Commercial applications of natural polymers-lignin, kerogen, amber, asphaltenes.	4
	4	Biodegradable polymers, examples. Biomedical applications of polymers.	2
V	**PRACTICALS – POLYMER CHEMISTRY**		**30**
		I . Determination of: 1. Ammonia content 2. Total solid content 3. Dry rubber content 4. KOH number. 5. Acid value 6. Iodine value 7. Estimation of hydroxyl groups 8. Estimation of nitrogen in polymeric and related samples.	
		II. Determination of: 1. Ash content; 2. Volatile matter 3. Metal (Cu, Fe and Th) content of dryrubber.	
		III. Qualitative analysis of plastics and rubbers	
		IV. Synthesis of different polymers involving various polymerization processes and techniques.	

References:

1. Malcon P. Steves, *Polymer chemistry-An introduction*, 3rd edition, Oxford University Press.
2. F. W. Billmayer, *Text book of Polymer Science*, 3rd edition, John Wiley &Sons.
3. R. Gowariker, N. V. Viswanathan&J. Sreedhar, *Polymer Science*, New Age International Publishers.
4. P. Bahadur& N. V. Sastry, *Principles of Polymer Science*, Narrora Publishing House, 2nd Edition, New Delhi.
5. Premamoy Ghosh, *Polymer Science & Technology*, 3rd edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi
6. G. Odian, *Principles of polymerization*, 3rd edition, John Wiley &Sons.
7. G. S. Misra, *Introductory Polymer Chemistry New age* International Publishers & Distributors, New Delhi.
8. K. Ahluwalia& A. Misra, *Polymer Science-A Text Book*, Ane Books, India, New Delhi.
9. J. R. Fried, *Polymer Science & Technology*, Prentice Hall of India Pvt. Ltd, New Delhi.
10. *Handbook for analysis of synthetic polymer and plastics*, J. Urbanski, W. Czerwinski, K. Janickaet al., Ellis Harwood Ltd.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Demonstrate a thorough understanding of molecular forces and bonding in polymers	R, U	PSO-1,2,3
CO-2	Identify the properties of polymers.	R, U	PSO-1,2,3
CO-3	demonstrate a comprehensive understanding of polymer degradation processes	U	PSO-1,2,3
CO-4	Realize the necessity of biodegradable substitutes for a sustainable development	U, A	PSO-1,2,3
CO-5	Develop practical skills in polymer synthesis and analysis	An, Ap	PSO-1,2,34,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: POLYMER CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO-1	PO-1,2,6 PSO-1,2,3	R, U	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	R, U	F, C	L	-
3	CO-3	PO-1,2,6 PSO-1,2,3	U	F, C	L	-
4	CO-4	PO-1,2,6 PSO-1,2,3	U, A	P	L	-
5	CO-5	PO-1,2,3,6 PSO-1,2,34,5	An, Ap	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	2	-	-	2	1	-	-	-	2	-	-
CO 2	3	2	2	-	-	2	1	-	-	-	2	-	-
CO 3	3	2	2	-	-	2	2	-	-	-	2	-	-
CO 4	2	2	2	-	-	2	1	-	-	-	2	-	-
CO 5	3	2	3	1	2	3	2	1	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE205**				
Course Title	**FORENSIC CHEMISTRY II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge on Criminology and Forensic Science 2. Understanding of legal provisions related to Forensic Science, Forensic Laboratories its roles and functions 3. UK3DSECHE205				
Course Summary	Recent Trends in Forensic Science, Techniques and Technologies, Crime scene: Types, Management, Role of police, Forensic Photography, Forensic Videography, Sketching				

Detailed Syllabus:

Module	Unit	Content **FORENSIC CHEMISTRY II**	Hrs 60
I	**BASICS IN FORENSIC SCIENCE, TECHNIQUES AND TECHNOLOGY**		**9**
	1.1	Recent Trends in Forensic Science- Environmental Forensics: Definition, Legal processes involving environmental forensic science	1
	1.2	Geo-forensics Global Positioning System; Basic principles and applications.	2
	1.3	Biometrics in Personal Identification: Introduction, Concepts of Biometric Authentication, Role in person Identification.	2
	1.4	Techniques and Technologies (Finger Print Technology, Face Recognition, IRIS, Retina Geometry, Hand Geometry, Speaker Recognition, Signature Verification and other forensic related techniques).	2
	1.5	Bioterrorism: Definition, Concepts of Biosecurity and microbial forensics, Weapons of mass destruction (WMD), mass-casualty weapons (MCW), NBC and CBRNE, Dirty Bombs.	2
II	**CRIME SCENE AND MANAGEMENT**		**18**
	2.1	Introduction, Importance, Types: Indoor and Outdoor, Primary and Secondary, Conveyance	2

	2.2	Crime Scene. Physical Evidences: Importance and Types of Physical Evidences.Initial Response	2
	2.3	Role of First Responding Officer, Duty Management, Role and duties of an Investigating Officer	2
	2.4	Role of Forensic Scientists, Forensic Doctors, Fire Brigade and Judiciary.	2
	2.5	Securing the Scene: Procedure and Precautions- Searching Methods: Types and Applications	2
	2.6	Recording the Scene: Forensic Photography, Forensic Videography, Sketching, Types and Procedure, Note Making	3
	2.7	Collection, Preservation and Packaging: Various Methods of Collection, Preservation and Packaging for different evidence.	3
	2.8	Chain of Custody and Forwarding: Significance of Chain of Custody	2
III	**POLICE AND FORENSIC SCIENCE**		**9**
	3.1	Relationship between police and forensic expert, Role of Police at the Crime scene, scientific help at crime scene	3
	3.2	Handling of various types of crime scenes by police, forensic teaching of police personals, forensic case documentation by Police	3
	3.3	Technological Advance and Police-3-D Scanning of the Scene, Introduction to Biosensors, Reconstruction of the Scene	2
	3.4	Portable Devices for Crime Investigation.	1
IV	**FORENSIC PHOTOGRAPHY**		**9**
	4.1	Photography: Basic Principles and Techniques, Exposing, Developing and Printing	3
	4.2	Modern Developments in Photography, Digital Photography	3
	4.3	Videography/High speed Videography, Crime Scene and Laboratory Photography.	3
V	**PRACTICALS:**		**30**
		1. Lab safety measures 2. Calibration and use of apparatus 3. Preparation of solutions of different concentration 4. Preparation of buffer solution (CH_3COONa/CH_3COOH and NH_4Cl/NH_4OH) 5. Determination of pH of various solutions 6. Determination of hardness of water **7.** Demonstration of various titration techniques.	

Reference

1. Saferstein*; Criminalistics- An Introduction of Forensic Science*, Prentice Hall Inc, USA, 2007.
2. Barry, A.J. Fisher; *Techniques of Crime Scene Investigation*, 7th Ed, CRC Press, New York, 2003.
3. Mordby, J. & Reckoning, D; *The Art of Forensic Detection*, CRC Press New York, 2003.
4. G.R. Chatwal; *Analytical Spectroscopy* 2nd Edn, Himalaya Publishing House New

Delhi,2002.
5. Aitken and Stoney; *The Use of Statistics in Forensic Science*, Ellis Horwood, New York, 1991.
6. Robertson and Vignaux; *Interpreting Evidence*, John Wiley, New York, 1995.
7. H.L. Blitzer and J. Jacobia; *Forensic Digital Imaging and Photography*, Academic Press, London, 2002
8. David R. Redsicker; *The Practical Methodology of Forensic Photography*- 2nd Ed. CRC Press, New York, 2001.
9. R. E. Jacobson, S. F. Ray, G. G. Attridge; *The Manual of Photography- Photographic and Digital Imaging*, N.R. Oxford
10. Swansan, C.R, Terrbles, L &Taylor, R.W; *Police Administration*, Prentice Hall, USA,1998
11. D.R. Redsicker, *The Practical Methodology of Forensic Photography*, 2nd Edition, CRC Press, Boca Raton (2000).

Course Outcomes

SI No.	Course Outcome: Upon completion of this course the student will be able to	Cognitive Level	PSO
1	Define the basic in recent trends in Forensic Science, Techniques and Technology	R	3
2	Explain the crime scene and evidences, sample preservation and recording the same	Ap	4
3	Demonstrate the role of police in forensic Science	U	5
4	Interpret the need of photography and its techniques in Forensic Science	U	3
5	Classify the different crimes and role of forensic science in solving	Ap	3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FORENSIC CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	3	R	C	L	
2	CO-2	4	Ap	F, C	L	
3	CO-3	5	U	F, C, P	L	
4	CO-4	3	U	F, C, P	L	

5	CO-5	3, 5	Ap	F, C, P, M	L/T	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PS O1	PS O2	PS O3	PS O4	PS O5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	2	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	-	-	-	-	-	-	-	-	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE206**				
Course Title	**CHEMISTRY OF NANOMATERIALS- II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK3DSECHE206				
Course Summary	This course provides an introductory understanding of the four primary classes of materials: metals, ceramics, polymers, and composites. Students will learn various processing techniques and the characterization of materials through diffraction, spectroscopy and microscopic techniques				

Detailed Syllabus:

Module	Unit	Course Description CHEMISTRY OF NANOMATERIALS- II	Hrs 75
I	**METALS AND ALLOYS**		**9**
	1.1	Introduction, Types of Metal Alloys: Ferrous Alloys and Nonferrous Alloys	3
	1.2	Mechanical properties of metals: strength, ductility, toughness	3
	1.3	Fabrication and Processing of metals Metal forming processes: Forging, rolling, extrusion, and drawing Casting techniques: sand, die, investment, lost foam, and continuous Thermal Processing of metals- Annealing, Heat treatment, precipitation hardening	3
II	**CERAMICS AND POLYMERS**		**18**
	2.1	Introduction, Types of Ceramics: Glasses, Clay Products, Refractories, Abrasives, Cements	3
	2.2	Mechanical properties of ceramics: brittle fracture, stress-strain	3
	2.3	Ceramic fabrication and Processing techniques: Glass-forming processes: Pressing, Blowing, Drawing, Fiber forming Particulate-forming Processes: Powder Pressing, Hydroplastic forming, Slip casting Tape casting Cementation	3

	2.4	Introduction, Types of Polymers: Plastics, Fibres, coatings, adhesives, films, foams	3
	2.5	Polymer Additives: Fillers, plasticizers, stabilizers, colorants, and flame retardants	3
	2.6	Polymer Synthesis and Processing techniques: Addition polymerization, condensation polymerization. Forming Techniques for Plastics- Compression transfer, injection, and blow, Extrusion and casting	3
III	**COMPOSITES**		**9**
	4.1	Introduction, Classification of composite materials: Particle-reinforced, Fiber-reinforced and structural	1
	4.2	Particle Reinforced composites: large-particle and dispersion-strengthened composites	3
	4.3	Fibrous reinforced composites: Fiber phase, matrix phase, classification based on matrix type: polymer-, metal-, and ceramic-matrix.	3
	4.4	Structural Composites- laminar composites and sandwich panels.	2
IV	**CHARACTERIZATION OF MATERIALS**		**9**
	5.1	Diffraction Techniques -X-ray diffraction (XRD), Electron diffraction	2
	5.2	Optical Spectroscopy- Infrared, Visible, and Ultraviolet, Raman	3
	5.3	Electron Microscopy - Scanning electron microscopy (SEM) Transmission electron microscopy (TEM)	2
	5.4	Surface Microscopy- Atomic-Force Microscopy; Scanning-Tunnelling Microscope	2
V	**OPEN MODULE PRACTICALS: A minimum of any7 practical experiments from sections A, B and C must be performed and reported.**		30
		A. Crystallization Techniques 1. Demonstration of various crystallization techniques i) Slow cooling ii) Slow evaporation from pure solvent iii) Slow evaporation from a mixture of solvents iv) Vapour diffusion 2. Grow crystals of any one metal carboxylate/metal tartrates/ potassium dihydrogen phosphate via any one of the crystallization techniques. **B. Synthesis of Materials** 1. Synthesis of polymers involving various polymerization processes and techniques. i) Polyaniline ii) Phenol Formaldehyde resin iii) Urea Formaldehyde Resin iv) Glyptal Resin 2. Synthesis of metal oxides/phosphate materials via sol-gel/ hydrothermal/ combustion routes i) ZnO ii) TiO_2 iii) Ca_3PO_4	

		C. Characterization of Materials Students should learn the indexing of at least one XRD pattern Crystal structure analysis using Powder X-ray diffraction pattern 1)Determine the type of cubic system (FCC, BCC, Simple cubic) by indexing PXRD data of the following i) Al ii)MgO iii) Ta iv) NaCl	

References

7. W.D Callister. Jr, *Materials Science and Engineering*, Wiley India Pvt. Ltd, 2007
8. Raghavan V, *Materials Science and Engineering*, 4th Edition, Prentice Hall of India, 1998
9. Joel I. Gersten and Frederick W. Smit, "*The Physics and Chemistry of Materials*", Wiley,
10. Fahlman, B.D., *Materials Chemistry*, Springer, 2007
11. James F. Shackelford, *Introduction to Materials Science for Engineers*
12. David G. Rethwisch, *Materials Science and Engineering: An Introduction*
13. William F. Smith and Javad Hashemi, *Foundations of Materials Science and Engineering*; 5th Edition
14. F.C. Campbell, *Elements of Metallurgy and Engineering Alloys*, ASM International, 2008.
15. J. Beddoes, M.J. Bibby, *Principles of Metal Manufacturing Processes*, Elsevier, 2003. 7. G.E. Dieter, Mechanical Metallurgy, McGraw-Hill, 3 rd ed., 1986.
16. E. Degarmo, J.T. Black and R.A. Kohser, *Materials and Processes in Manufacturing*, 9th ed., Wiley, 2002.
17. S. Kalpakjian, S.R. Schmid, *Manufacturing Engineering and Technology*, 6th ed., Pearson, 2009
18. *Handbook for analysis of synthetic polymer and plastics*, J. Urbanski, W. Czerwinski, K. Janicka et al., Ellis Harwood Ltd
19. A.I.Vogel, "*Elementary Practical Organic Chemistry*" Longmans

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the types of metal alloys, its fabrication, processing and properties	U	1,2
CO-2	Discuss different types of ceramic materials and its fabrication and processing techniques	U	1,3
CO-3	Describe types of polymers, polymerization techniques and the importance of incorporating additives into polymeric materials and, indicate how it modifies the properties	U, Ap	1,3

CO-4	Name the three main divisions of composite materials and cite the distinguishing feature of each.	U	1,3
CO-5	Equip with the knowledge and understanding of various techniques used to synthesize and characterize materials.	U, Ap	1,2,4
CO-6	Describe the principles and applications of various diffraction techniques, optical spectroscopy methods and microscopy techniques	U, Ap	1,2,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-

Name of the Course: CHEMISTRY OF NANOMATERIALS- II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2	U	F, C	L	-
2	CO-2	1,3	U	C	L	-
3	CO-3	1,3	U, Ap	M	L	-
4	CO-4	1,3	U	M	L	-
5	CO-5	1,2,4	U, Ap	P	L	-
6	CO-6	1,2,4,5	U, Ap	C, P	-	p

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	-	-	-	3	2	-	-	-	-	-	-
CO 2	1	-	3	-	-	1	3	-	-	-	-	-	-
CO 3	3	-	2	-	-	3	3	-	-	-	-	-	-
CO 4	1	-	3	-	-	3	2	-	-	-	-	-	-
CO 5	3	3	2	-	-	2	2	-	-	-	-	-	-
CO 6	2	3	3	-	2	2	3	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓		✓
CO 5	✓	✓		✓
CO 6	✓		✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4DSECHE207**				
Course Title	**MEDICINAL AND PHARMACEUTICAL CHEMISTRY II**				
Type of Course	**DSE**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	2 hours	5
Pre-requisites	1. General knowledge on primary and secondary metabolites in natural product 2. UK3DSECHE207				
Course Summary	The course covers a broad range of topics related to natural product extraction, herbal cosmetics, natural drug leads, and separation techniques. General methods of preparation and evaluation of herbal cosmetics, particularly skincare products. Merits and demerits of natural products with method of isolation and latest technology for purification. Identification of impurities in drug and its formulation.				

Detailed Syllabus:

Module	Unit	Content MEDICINAL AND PHARMACEUTICAL CHEMISTRY II	Hrs 75
I	**HERBAL TECHNOLOGY IN DRUG PREPARATION**		**9**
	1.1	Types of extracts; Extraction methods such as Maceration, Percolation, Super Critical Fluid Extraction,	3
	1.2	Distillation Methods; Methods for drying of extracts.	3
	1.3	Selection and purification of solvents for extraction.	3
II	**HERBAL COSMETICS**		**9**
	2.1	General method of preparation and evaluation of Herbal Cosmetics such as Skin care products	2
	2.2	Herbal products of cosmetic importance such as Aloe vera, Neem, Henna,	2
	2.3	Acacia concinna pods, Citrus aurantium peel, Liquorice, Sandal wood,	2
	2.4	Olive oil, Wheat germ oil, Almond oil and Tea – tree oil with special emphasis on their source, active principles and cosmetic properties.	3
III	**NATURAL DRUG LEAD**		**9**
	3.1	Natural Products as drug leads	1
	3.2	A brief account of exploration of biologically active/inactive proto types towards newer and better semi-synthetic or synthetic drugs	2

	3.3	uses, merits and demerits (if any). i) Quinine (Ex. Aminoquinolines) ii) Morphine	2
	3.4	iii) Salicin iv) Ephedrinev) Atropine vi) Cocaine vii) Ergot alkaloids	2
	3.5	Carotene xi) Diosgenin	2
IV		**SEPARATION TECHNIQUES OF CRUDE DRUG**	**18**
	4.1	Introduction to chromatographic methods: TLC and HPTLC	3
	4.2	Column chromatography (open) and its modifications like flash, vacuum liquid and medium pressure chromatographies, Gel Permeation technique.	3
	4.3	HPLC & GLC,The various column materials used in these techniques.	3
	4.4	Electrophoresis (Gel and Paper)	2
	4.5	Paper Chromatography (Tea and Coffee powder)	2
	4.6	Super Critical Chromatography, Circular Counter Current Chromatography	2
	4.7	Ion Exchange Methods,The relative advantages and limitations of the techniques.	3
V		**PRACTICAL I- MEDICINAL AND PHARMACEUTICAL CHEMISTRY**	**30**
	1	I)Limit Test; Chloride, Sulphate, Fe and Arsenic	
	2	II)Formulation of the following dosage forms as per monograph standards and dispensing with appropriate packaging and labelling i)Simple syrup- Piperazine citrate elixir, Aqueous Iodine solution ii)Emulsion: Castor oil emulsion, Cod liver oil emulsion iii)Suspension: Calamine lotion, Magnesium hydroxide mixture iv)Emulsions-Turpentine Liniment Liquid paraffin emulsion	
	3	III)Estimation of Ca and Mg in water	

Reference:

1. *Medicinal Natural Products* by Paul M. Deweek.
2. *Pharmacognosy & Pharmacobiotechnology* by Ashutosh kar
3. *Natual Excipients* by R.S. Guad, Surana et. al.
4. *Indian Medicinal Plants* Volumes by Kirtikar K.R. and Basu B.D.
5. *A handbook of Cosmetics* by B.M. Mithal & RN Saha
6. *Pharmacognosy & Phytochemistry* by Vinod Rangari

References: Practicals

1. H.C. Ansel et al., Pharmaceutical Dosage Form and Drug Delivery System, Lippincott Williams and Walkins, New Delhi.
2. Francoise Nieloud and Gilberte Marti-Mestres: Pharmaceutical Emulsions and Suspensions, Marcel Dekker, INC, New York.
3. M.E. Aulton, Pharmaceutics, The Science& Dosage Form Design, Churchill Livingstone, Edinburgh. 4. Indian pharmacopoeia.

Course outcome

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Innovations in extraction technology and methodologies, Sustainable approaches to extract production and processing, Future applications of extracts in pharmaceuticals and functional foods.	U	PSO-1,2
CO-2	Factors influencing solvent selection for extraction, Types of solvents used in extraction: polar, non-polar, and supercritical fluids, Purification techniques for solvent recovery and recycling	R, U	PSO5
CO-3	Isolation and properties of different alkaloids from different plants, Pharmacological effects and therapeutic uses Semi-synthetic and synthetic derivatives of alkaloids Side effects.	R, U, A	PSO4
CO-4	Principles and procedures of TLC, Applications and advantages of TLC in qualitative analysis, Introduction to HPTLC and its enhanced performance capabilities, Comparison between TLC and HPTLC techniques	R, U, A	PSO4
CO-5	Principles and procedures of Paper Chromatography, Skill in doing paper chromatography Applications of supercritical extraction	R, C	PSO3
CO6	Develop an ability to identify and estimate estimate the amount of ions and develop skill to formulate various medicament	A	PSO5
CO7	Learn the principles and analytical techniques for quantifying calcium and magnesium ions in water samples. Acquire skills in sample preparation, calibration of analytical instruments, and data analysis.	A, C	PSO1,2,3

S-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: MEDICINAL AND PHARMACEUTICAL CHEMISTRY II

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)

1	CO-1	PSO-1,2	U	F	L	-
2	CO-2	PSO5	R, U	C, P	L/T	-
3	CO-3	PSO4	R, U, A	F, C	L/T	-
4	CO- 4	PSO4	R, U, A	C, P	L	-
5	CO- 5	PSO3	R, C	C, P	L/T	-
6	CO 6	PSO5	A	P	-	P
7	CO 7	PSO1,2,3	A, C	p	-	p

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	2	3	-	-	-	-	-	1	-	-	-	-	-
CO 2	-	-	-	-	3	2	-	-	-	-	-	-	-
CO 3	-	-	-	2	-	-	-	1	-	-	-	-	-
CO 4	-	-	-	2	-	-	-	2	-	-	-	-	-
CO 5	-	-	3	-	-	-	-	-	-	-	3	-	-
CO 6	-	-	-	-	2	-	-	-	1	-	-	-	-
CO7	1	2	3	-	-	-	-	-	-	-	1	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓
CO 6		✓		
CO7	✓			

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4SECCHE200**				
Course Title	**WATER QUALITY ANALYSIS**				
Type of Course	**SEC**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	-	2 hours	4
Pre-requisites	1. Basic knowledge, practical skills and interest in chemistry				
Course Summary	The course cover water quality parameters, different types of water, removal of hardness of water, qualitative and quantitative analysis of different contaminant of water, different types of contaminants of water and real sample analysis f water and its application in environment.				

Detailed Syllabus:

Module	Unit	Content	Hrs
	WATER QUALITY ANALYSIS		**45**
I	**QUALITY PARAMETERS FOR DRINKING WATER**		**6**
	1	Contaminants Vs pollutants	1
	2	Water quality parameters and their interaction	2
	3	Physical and chemical characteristics - turbidity, colour – temperature - chemical constituents, taste, colour, acidity, alkalinity - CO_2, pH.	3
II	**HARD AND SOFT WATER, CHEMICAL AND BIOLOGICAL CONTAMINATION OF WATER**		**15**
	4	Classification of water, difference between soft and hard water	2
	5	Causes of hardness, removal of temporary and permanent hardness	2
	6	Standard for drinking water as per WHO and BIS specifications, application in environmental situation.	3
	7	Chemical contaminant- classification- inorganic, organic-health effects, and removal.	4
	8	Biological contaminants- type of contaminants, health effects and remedial measures**.**	4
III	**QUALITATIVE AND QUANTITATIVE ANALYSIS**		**9**
	9	Chloride, Nitrite, nitrate, phosphate, ammonia	3
	10	BOD, COD, DO, pH	3
	11	Estimation of hardness of water, Jar test- water quality enhancement.	3
IV	**REAL SAMPLE ANALYSIS - CASE STUDIES**		**6**

	12	Collection of samples from different area	4
	13	Application in environment	2
V	**OPEN ENDED MODULE:**		**9**
	14	Hands on sessions, seminar presentations, group discussions, debates, quizzes, case studies etc on the above modules - field trip to a local water body to collect samples - analyze the collected water samples for various parameters such as pH, dissolved oxygen, turbidity, temperature, conductivity, nutrient levels etc and compare the results with established water quality standards – presentation of the findings and remediation proposals - designing educational materials (brochures, posters etc) about water quality and its importance for public health - **(Or any other related activities introduced by the teacher)**	

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1. De., *Environmental Chemistry*, 6th Edition, New Age International.
2. P.K.Goel, *Water Pollution*, Causes, Effects and Control, New Age International.
3. Kochu Baby Manjooran, *Modern Engineering Chemistry* (Kerala University), Kannatheri Publications.
4. Shashi Chowla, *Engineering Chemistry*, Dhanpat Rai Publishing Company.
5. P. C. Jain and Monika Jain, "*Engineering Chemistry*" Dhanpat Rai Publishing Company (P) LTD, New Delhi, 15th edition, 2015.
6. Dr.K. Mukkanti, *Environmental studies*, S. Chand &Camp Ltd.
7. R.K. Trivedi and P.K. Geol, *Chemical and biological method for water pollution.*

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Understand important parameters for measuring water quality.	U	PSO-1,2,3,4
CO-2	Develop awareness about water quality criteria and standards, and their relation to public health and environment	Ap	PSO-1,2,3,4
CO3	Apply water quality tests and analyze how the parameters relate to each other.	An	PSO-1,2,3,4
CO4	Classify water into soft and hard	Ap	PSO-1,2
CO5	Identify the contaminants in water and skill to develop water analysis	E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: WATER QUALITY ANALYSIS

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO1	PO-1,6,8 PSO-1,2,3,4	U	F, C	L	-
2	CO-2	PO-1,2,3,6,8 PSO-1,2,3,4	Ap	C, P	L	-
3	CO3	PO-1,2,3,6,8 PSO-1,2,3,4	An	C, P	L	-
4	CO4	PO-1,6 PSO-1,2	Ap	C, P	L	-
5	CO5	PO-1,2,3,6,8 PSO-1,2,3,4,5	E	P, M	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	2	2	-	1	-	-	-	-	2	-	2
CO 2	2	3	3	3	-	1	2	2	-	-	2	-	2
CO 3	2	3	3	2	-	1	2	2	-	-	2	-	2
CO 4	3	3	-	-	-	1	-	-	-	-	2	-	-
CO 5	2	3	3	3	2	2	2	3	-	-	3	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5	✓		✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4SECCHE201**				
Course Title	**PRACTICAL SKILLS IN CHEMISTRY**				
Type of Course	**SEC**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge, practical skills and interest in chemistry				
Course Summary	The course covers lab safety measures, preparation of standard solutions, measurement of pH of different samples, volumetric analysis and salt analysis.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		PRACTICAL SKILLS IN CHEMISTRY	**45**
I	**LAB SAFETY**		**6**
	1	Risk, Hazard, Chemical Hazard, Symbols, Incompatible chemicals,	1
	2	Storage and handling of chemicals, handling of acids, ethers, toxic and poisonous chemicals, antidotes.	2
	3	Fire Classification, Occupational, Health and Safety Administration,	1
	4	Personal Protective Equipment (PPE). First aid procedure,	1
	5	Safety protocols and procedures.	1
II	**PREPARATION OF STANDARD SOLUTIONS**		**6**
	6	Concentration terms: Molarity, molality, normality, mole fraction, weight percentage, ppm, (Simple numerical problems).	2
	7	Primary and secondary standards, criteria for primary standards,	1
	8	Preparation of standard solutions	1
	9	Preparation of decinormal solutions - sodium carbonate and oxalic acid solutions.	2
III	**MEASUREMENT OF pH**		**6**
	10	pH -definition, equation, pH scale, (simple numerical problems)	1
	11	Determination of pH of different samples using pH paper, universal indicator and pH meter.	2
	12	pH –fruits, vegetables, Milk, water, soap.	2
	13	Natural indicator – preparation.	1
IV	**BASIC CONCEPTS OF QUANTITATIVE & QIALITATIVE ANALYSIS**		**18**

	14	Introduction to titration – Titration, titrant, titrate, acid- base indicator, endpoint, and equivalence point.	1
	15	Principle of titration, standardization of solutions	1
	16	Estimation of NaOH, HCl, Na_2CO_3, Oxalic acid, Permanganometric titrations.	7
	17	Introduction to anions and cations, common ion effect, solubility product	2
	18	Identification – ammonium chloride, barium carbonate, zinc nitrate, aluminium sulphate and lead acetate.	7
V	**OPEN ENDED MODULE:**		**9**
	19	lab safety orientation sessions for common laboratory hazards, safety equipment emergency procedures – identification of potential hazards and suggestions improvements in the lab, safety topics relevant to their field of study, hands-on sessions to practice of preparing standard solutions, designing experiments to estimate particular solutions of acid/base/reducing agent/oxidizing agent, hands on sessions with pH meters or pH indicators of aqueous solutions with unknown pH values etc **(Or any other related activities introduced by the teacher)**	9

REFERENCES:

1. V.V. Ramanujam, *Inorganic Semi Micro Qualitative Analysis*, 3rd edition, the National Publishing Company, Chennai, 1974.
2. *Vogel's Text Book of Inorganic Qualitative Analysis*, 4th edition, ELBS, London, 1974.
3. D.A. Skoog, D.M. West and F.J. Holler, *Analytical Chemistry: An Introduction*, 5th edition, Saunders college publishing, Philadelphia, 1990.
4. U.N. Dash, *Analytical Chemistry: Theory and Practice*, Sultan Chand and sons Educational Publishers, New Delhi, 1995.
5. R.A. Day Jr. A.L. Underwood, *Quantitative Analysis*, 5th edition, Prentice Hall of India Private Ltd., New Delhi, 1988.
6. *Vogel's Text Book of Inorganic Quantitative Analysis*.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the safety methods in laboratory	U	PSO-1,2,3
CO-2	Develop the habit of accurate manipulation and an attitude of critical thinking	Ap	PSO-1,2,3,4

CO 3	Develop analytical skills in inorganic qualitative analysis.	An	PSO-1,2,3
CO 4	Analyze the various coloured chemical reactions of metal ions	An	PSO-1,2
CO 5	Develop skills in volumetric analysis	Ap	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PRACTICAL SKILLS IN CHEMISTRY

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U	F, C	L	-
2	CO-2	PO-1,2,3,6 PSO-1,2,3,4	Ap	C, P	L	-
3	CO 3	PO-1,2,3,6 PSO-1,2,3	An	C, P	L	-
4	CO 4	PO-1,3,6 PSO-1,2	An	C, P, M	L	-
5	CO 5	PO-1,6 PSO-1,2,3	Ap	P, M	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	2	-	-	-	-	2	-	-
CO 2	2	2	2	2	-	1	2	2	-	-	2	-	-
CO 3	3	3	2	-	-	1	2	2	-	-	2	-	-
CO 4	2	3	-	-	-	1	-	2	-	-	2	-	-
CO 5	3	3	-	-	-	1	-	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4VACCHE200**				
Course Title	**SUSTAINABLE CHEMISTRY**				
Type of Course	**VAC**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	The course covers biomass assessment, techniques, waste management, biofuel, bio hydrogen production, polymers from biomass, corrosion management and renewable energy resources.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		SUSTAINABLE CHEMISTRY	**45**
I	**INTRODUCTION TO BIOMASS**		**6**
	1	Biomass: Biomass resources, types, production, classification, and characterisation	2
	2	Techniques for biomass assessment.	1
	3	Concept of Waste segregation, management, and treatment.	3
II	**BIOFUEL & POLYMERS FROM BIOMASS**		**15**
	4	Bio ethanol and Biodiesel Production - Economics - Recent developments. Energy farming	3
	5	Biomass to gaseous fuel production-, Biogas technology - biogas plants – design consideration – applications.	3
	6	Bio hydrogen Production, Concept of Bio refinery.	2
	7	Natural biopolymers: proteins (silk, wool, hair etc.), polysaccharides, collagen	2
	8	Biopolymers from renewable resources- casein, natural rubber, and cellulose.	2
	9	Biosynthesis of biodegradable polymers (polyhydroxyalkanoates etc). Synthetic biopolymers: polylactic acid and its co-polymers, aliphatic polyesters, polyethylene oxides.	3
III	**CORROSION MANAGEMENT**		**9**
	10	Corrosion: Erosion and corrosion, wet corrosion and dry corrosion, Factors affecting corrosion	3

	11	Coatings as a method of corrosion prevention (Tinning, Galvanizing, Painting Electroplating, Anodising). Cathodic protection and Anodic protection.	3
	12	Corrosion resistant materials – alloys – Details different types of steel, properties and applications, anti-rest solutions	3
IV	**RENEWABLE ENERGY SOURCES**		**6**
	13	Fundamentals of Sustainable Energy & Development	1
	14	Introduction to Renewable Energy – Need of switching to Renewable Energy sources, Difference between Renewable & Non-renewable sources	2
	15	Main sources – solar, wind, tidal, biomass, geothermal - Applications, Advantages & Disadvantages of Renewable Energy.	3
V	**OPEN ENDED MODULE:**		**9**
	16	Seminar presentations, group discussions, debates, quizzes, case studies etc on the above modules –regional assessment of biomass resources available for energy production - biofuel production process using biomass feedstocks - biodegradable polymers from biomass-derived feedstocks - effective corrosion management strategies - renewable energy policies at local, national or international level, etc. **(Or any other related activities introduced by the teacher)**	

REFERENCES

1. Ted Weyland, *Bioenergy: Sustainable Perspectives*, Callisto Reference. ISBN: 978-1-632-39633-4.
2. *Corrosion and corrosion control* Ublig, H. H. Latest edition.
3. Kulkarni, V. and Ramachandra, T.V., "*Environment Management*", TERI Press. 2009.
4. *Non-conventional Energy Sources*; G.D.Rai; 2011; Fifth Edition, Khanna Publishers.
5. Capareda S, *Introduction to biomass energy conversion*, CRC Press. ISBN: 978-1-466-51333-4.
6. Brown RC and Stevens C, *Thermo-chemical Processing of Biomass: Conversion into Fuels, Chemicals and Power*, Wiley and Sons. ISBN: 978-0- 470-72111-7.
7. Vaughn C. Nelson, Kenneth L. Starcher, *Introduction to Bioenergy (Energy and the Environment*), CRC Press. ISBN: 978-1-498-71698-7.
8. Yebo Li and Samir Kumar Khanal, *Bioenergy: Principles and Applications*, Wiley-Blackwell. ISBN: 978-1-118-56831-6.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss various biomass resources, techniques of assessment and waste management.	U	PSO-1,2,3

CO-2	Apply the production of bio hydrogen fuel	Ap	PSO-1,2,3,4
CO-3	Synthesis of biodegradable polymers from biomass	Ap	PSO-1,2,3,4,5
CO-4	Develop methods for producing corrosion resistant materials	Ap	PSO-1,2,3,4,5
CO-5	Discuss various types of renewable energy resources and their advantages	U	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: SUSTAINABLE CHEMISTRY

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U	F, C	L	-
2	CO-2	PO-1,2,3,6,8 PSO-1,2,3,4	Ap	C, P	L	-
3	CO-3	PO-1,2,3,6,8 PSO-1,2,3,4,5	Ap	P	L	-
4	CO-4	PO-1,2,3,6,8 PSO-1,2,3,4,5	Ap	P	L	-
5	CO-5	PO-1,2,3,6,7,8 PSO-1,2,3	U	F, C	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	2	-	-	2	-	-	-	-	2	-	-
CO 2	2	3	3	3	-	1	2	2	-	-	2	-	2
CO 3	2	3	3	3	2	1	2	2	-	-	2	-	2
CO 4	2	3	3	3	2	2	2	2	-	-	2	-	2
CO 5	3	2	3	-	-	3	2	2	-	-	3	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5	✓		✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK4VACCHE201**				
Course Title	**SCIENTIFIC COMMUNICATION AND ETHICS**				
Type of Course	**VAC**				
Semester	4				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	1. Basic knowledge and interest in science				
Course Summary	The course covers scientific communication methods, data bases, intellectual property rights, ethics for publication and metrices for journal.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		SCIENTIFIC COMMUNICATION AND ETHICS	**45**
I	**METHOD OF SCIENTIFIC COMMUNICATION**		**6**
	1	Need for science communication - Importance and use of science communication	1
	2	Public Understanding of Science (PUS) - Science popularization: programmes, organizations, individuals - Method of science - Scientific temper	2
	3	Sources of scientific information – books, scientific reports, scientific journals, magazines, feature syndicates, leaflets, tabloids, wall magazines, speeches, seminars, press releases, databases, encyclopaedias on science, etc	2
	4	Comparative study of science sections and supplements carried in Indian / foreign newspapers and science magazines.	1
II	**SCIENTIFIC DIGITAL DATA BASE**		**9**
	5	Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, Metrics: h-index, g-index, i10 index, altmetrics. E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers.	3
	6	Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-Databases, ChemSpider, Science Direct, SciFinder, Scopus.	3
	7	Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.	3

III	**INTELLECTUAL PROPERTY RIGHTS & ETHICS IN PUBLICATIONS**		**15**
	8	Concepts and Evolution: Introduction to Intellectual Property Rights,	1
	9	Evolution of Intellectual Property Laws. Standards and Concepts in Intellectual Property,	2
	10	Law of Intellectual Property and Ethical Issues, Knowledge Driven Economy and IPR	2
	11	Intellectual Property Rights in India and abroad. Law of Patents.	2
	12	Publication ethics: definition, introduction and importance,	2
	13	Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.	3
	14	Conflicts of interest, Copy right, royalty, Plagiarism, citation, acknowledgement, reproducibility and accountability.	3
IV	**METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS:**		**6**
	15	Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation.	3
	16	Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.	3
V	**OPEN ENDED MODULE:**		**9**
	17	Seminar presentations, group discussions, debates, quizzes, case studies etc on the above modules - discussion on ethical considerations in scientific research and publishing - designing experiments or surveys - collecting and analysing data - writing up the findings in a scientific paper - case studies on the violation of intellectual property rights etc. **(Or any other related activities introduced by the teacher)**	9

REFERENCES

1. Jane Gregory and Steve Miller, *Science in Public: Communication, Culture, and Credibility, Plenum*, New York, 1998.
2. James G, Paradis and Muriel L. Zimmerman, *The MIT Guide to Science and Engineering Communication.* MIT Press, UK, 2002.
3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. *An introduction to Research Methodology,* RBSA Publishers Bird, A. (2006). Philosophy of Science. Routledge.
4. MacIntyre, Alasdair (1967) *A Short History of Ethics.* London.
5. P. Chaddah (2018) *Ethics in Competitive Research: Do not get scooped; do not get plagiarized,* ISBN: 978-9387480865.
6. Resnik, D.B. (2011). *What is ethics in research and why is it important.* National Institute of Environmental Health Science, 1-10.
7. *Practicing communication ethics.* Boston, MA: Allyn & Bacon.
8. Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry.* Oxford University Press.
9. Dawson, C. (2002). *Practical research methods.* UBS Publishers, New Delhi.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the scientific communication methods and sources of scientific information	U	PSO-1,2,3
CO-2	Analyse the different scientific databases	An	PSO-1,2,3
CO- 3	Discuss the IPR, Laws and patent	U	PSO-1,2,3
CO- 4	Discuss the publication ethics and conflict of interest	U	PSO-1,2,3,4
CO- 5	Discuss the impact factor of journals, citation index and metrics	U	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: SCIENTIFIC COMMUNICATION AND ETHICS

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,8 PSO-1,2,3	U	F, C	L	-
2	CO-2	PO-1,2,8 PSO-1,2,3	An	P	L	-
3	CO- 3	PO-1,8 PSO-1,2,3	U	F, C	L	-
4	CO- 4	PO-1,8 PSO-1,2,3,4	U	C, P	L	-
5	CO- 5	PO-1,8 PSO-1,2,3,4	U	C, P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	3	-	-	1	-	-	-	-	-	-	3
CO 2	3	3	3	-	-	2	2	-	-	-	-	-	3
CO 3	2	2	3	-	-	2	-	-	-	-	-	-	3
CO 4	2	2	2	2	-	1	-	-	-	-	-	-	3
CO 5	2	2	3	2	-	2	-	-	-	-	-	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		

SEMESTER 5

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSCCHE300**				
Course Title	**INORGANIC CHEMISTRY IIIA**				
Type of Course	**DSC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. UK1DSCCHE100 2. UK4DSCCHE200				
Course Summary	This course deals with the electronic configuration, general characteristics, stability of oxidation states, and the formation of complexes by transition and inner transition elements, their color, magnetic, and catalytic properties, along with the preparation, properties, and uses of their specific compounds. Furthermore, the course covers coordination chemistry, organometallic and bioinorganic chemistry, metallurgy, and practical experiments in gravimetric analysis, providing students with a holistic understanding of the chemistry of transition and inner transition elements.				

Detailed Syllabus:

Module	**Unit**	**Content** **INORGANIC CHEMISTRY IIIA**	**Hrs** **75**
I	**TRANSITION AND INNER TRANSITION ELEMENTS**		**9**
	1	Electronic Configuration and General Characteristics - Overview of transition elements and inner transition elements - Electronic configuration - General characteristics including oxidation states, ionization enthalpy, and enthalpy of atomization - Variation of ionization enthalpy across the 3d series - Introduction to standard electrode potentials (E^o M2+/M & E^o M3+/M2+).	2
	2	Stability of Higher Oxidation States and Formation of Complexes - Factors affecting stability of higher oxidation states - Formation of complexes and ligand interactions - Importance of coordination chemistry in transition metal complexes	1
	3	Colour, Magnetic Property, and Catalytic Property - Explanation of colour in transition metal complexes (d-d transitions)	2

		- Magnetic properties including paramagnetism and diamagnetism - Catalytic properties and their industrial applications - Explanation of relativistic effects in heavier transition elements	
	4	Preparation, Properties, and Uses of Specific Compounds - Detailed study of $K_2Cr_2O_7$, $KMnO_4$ and $TiCl_4$ - Preparation methods, physical and chemical properties - Industrial and laboratory uses of these compounds - Important applications of transition metals in various fields	2
	5	Electronic Configuration, General Properties, and Reactions of Lanthanides and Actinides - Introduction to lanthanides and actinides - Electronic configurations and general properties - Reactions and similarities with transition elements - Overview of unique properties and applications of lanthanides and actinides	2
II	**COORDINATION CHEMISTRY**		**18**
	6	Ligands and Their Classifications - Introduction to ligands in coordination chemistry - Classification of ligands based on donor atoms: monodentate, bidentate, polydentate - Classification based on charge: anionic, cationic, neutral - Discussion on coordination number and coordination geometry	1
	7	Nomenclature of Complexes - Guidelines for naming coordination compounds - Nomenclature of complexes with simple and complex ligands - Examples illustrating the naming process	1
	8	EAN Rule, Chelates, and Stability of Complexes - Explanation of the EAN (Effective Atomic Number) rule - Concept of chelation and chelating ligands - Factors affecting the stability of complexes: size and charge of metal ion, nature of ligands, and coordination number	2
	9	Isomerism in Complexes - Overview of structural isomerism and stereoisomerism in coordination compounds - Types of structural isomerism: linkage isomerism, coordination isomerism, and ionization isomerism - Types of stereoisomerism: geometrical isomerism and optical isomerism	2
	10	Bonding in Complexes - V.B. Theory - Introduction to Valence Bond Theory (V.B. Theory) for coordination compounds - Explanation of bonding between metal ion and ligands - Hybridization and overlap of atomic orbitals - Limitations and applications of V.B. Theory	2
	11	Crystal Field Theory (CFT) Applied to Various Complex Geometries - Overview of Crystal Field Theory (CFT)	2

		- Application of CFT to octahedral, tetrahedral, and square pyramidal complexes - Explanation of splitting of d orbitals in the presence of ligands - Factors affecting crystal field splitting: nature of metal ion, ligand strength, and geometry of complex	
	12	Factors Affecting Crystal Field - Detailed discussion on factors influencing crystal field splitting energy - Ligand field stabilization energy (LFSE) - Effects of coordination number, ligand field strength, and nature of ligands on crystal field splitting - Applications of crystal field theory in predicting magnetic properties and colours of coordination compounds.	1
	13	Spectrochemical Series and Crystal Field Stabilization Energy (CFSE) - Introduction to the spectrochemical series - Explanation of ligands' ability to cause d-orbital splitting - Relationship between ligand strength and splitting energy - Calculation and significance of Crystal Field Stabilization Energy (CFSE) - Examples illustrating the spectrochemical series and CFSE values	1
	14	Magnetic Properties and Color of Metal Complexes - Explanation of magnetic properties: paramagnetism, diamagnetism, and ferromagnetism - Factors influencing magnetic behavior in metal complexes - Relationship between electronic configuration, CFSE, and magnetic properties - Relationship between ligand field strength, d-d transitions, and color in metal complexes	1
	15	Effects of Crystal Field Splitting - Overview of crystal field splitting in octahedral complexes - Explanation of the effects of crystal field splitting on electronic configuration and stability - Relationship between ligand field strength and the magnitude of splitting - Interpretation of spectrochemical series in terms of crystal field splitting	1
	16	Jahn-Teller Effect and Tetragonal Distortion - Introduction to the Jahn-Teller effect in transition metal complexes - Explanation of distortion in coordination geometries caused by Jahn-Teller effect - Focus on tetragonal distortion of octahedral complexes - Examples illustrating the Jahn-Teller effect in coordination chemistry	1
	17	- Application of coordination compounds in qualitative and quantitative analysis - Use of EDTA (Ethylenediaminetetraacetic acid) as a complexometric titrant - Examples of complexometric titrations and their significance in analytical chemistry	1
	18	Reactions of Metal Complexes - Labile and Inert Complexes	2

		- Explanation of labile and inert metal complexes - Ligand substitution reactions: SN1 and SN2 mechanisms - Factors influencing the rate of ligand substitution reactions - Examples illustrating labile and inert complexes and their reactions - Ligand substitution reactions and their applications - Review of key concepts including spectrochemical series, CFSE, magnetic properties, crystal field splitting, Jahn-Teller effect, and application in metallurgy and analysis - Importance of coordination compounds in various fields.	
III	**ORGANOMETALLIC CHEMISTRY**		**9**
	19	Definition and Nomenclature of Organometallic Compounds - Introduction to organometallic compounds - Definition and significance in chemistry - Nomenclature guidelines for organometallic compounds.	1
	20	Classification and 18-Electron Rule - Classification of organometallic complexes as sigma, pi, and mixed complexes - Explanation of the 18-electron rule in organometallic chemistry - Examples illustrating the application of the 18-electron rule	1
	21	Metal Carbonyls - Overview of metal carbonyls - Classification into mononuclear and polynuclear complexes - Detailed study of metal carbonyls with examples using Fe, Co, and Ni - Preparation methods and key properties of metal carbonyls	1
	22	Bonding in Organometallic Compounds - Explanation of bonding in organometallic compounds without using Molecular Orbital Theory (MOT) - Detailed analysis of bonding in specific compounds like ferrocene, dibenzene chromium, and Ziese's salt - Introduction to dinitrogen complexes and their bonding characteristics	3
	23	Applications of Organometallic Compounds - Overview of the diverse applications of organometallic compounds - Industrial applications in catalysis, synthesis, and materials science - Environmental and pharmaceutical applications	3
IV	**METALLURGY**		**9**
	25	Methods of Concentration of Ore - Overview of ore concentration techniques - Gravity separation: principles and applications - Froth flotation: process and its significance in mineral processing - Magnetic separation: principles and applications in separating magnetic ores - Leaching: introduction to different leaching methods such as acid leaching and cyanide leaching - Electrostatic separation: principles and applications in separating non-conductive minerals	1

		- Automated ore sorting: modern techniques for ore sorting based on optical properties or sensors - Dewatering: methods to remove water from concentrated ore slurry	
	26	Preliminary Processes - Calcination and Roasting - Definition and importance of calcination and roasting in metallurgy - Explanation of calcination and roasting processes - Differences between calcination and roasting - Examples illustrating the application of calcination and roasting in ore treatment	1
	27	Methods of Extracting Metal from Concentrated Ore - Overview of electrometallurgy as a method for extracting metals from ores - Metallurgy of Aluminium: Bayer's process, Hall-Héroult process - Sodium-pyrometallurgy: extraction of sodium by Downs process - Pyrometallurgy: principles and applications in extracting metals from ores using heat - Discussion on specific examples of pyrometallurgical processes	2
	28	Metallurgy of Iron and Zinc - Detailed study of the metallurgy of iron, including blast furnace process and refining methods - Metallurgy of zinc: overview of the extraction process from zinc blende (sphalerite)	1
	29	Aluminothermy, Auto-reduction, and Hydrometallurgy - Explanation of aluminothermy and its applications in extracting metals - Auto-reduction: self-reduction processes in metallurgy - Hydrometallurgy: principles and applications of extracting metals using aqueous solutions.	1
	30	Metallurgy of Silver and Gold - Overview of the metallurgy of silver and gold - Methods of extraction including cyanidation, amalgamation, and smelting - Importance of purification steps in obtaining high-purity silver and gold	1
	31	Purification of Crude Metal - Explanation of purification techniques such as distillation, liquation, and zone refining - Electrorefining: principles and applications in refining metals like copper - Chromatographic techniques: separation methods based on differential migration - Introduction to vapor phase refining processes like Mond's process and Van Arkel process	2
V	**PRACTICALS: GRAVIMETRIC ANALYSIS**		**30**
		A minimum of 5 practical experiments from any sections must be performed and reported.	
	32	**A. Estimations using silica crucible**	20
		Estimation of water of crystallization in hydrated Bariumchloride	
		Estimation of Barium as Barium sulphate	

		Estimation of sulphate as Barium sulphate	
		Estimation Iron as Fe_2O_3	
		Estimation Calcium as $CaCO_3$	
		Estimation Aluminium as Al_2O_3	
		Estimation Magnesium as $Mg_2P_2O_7$	
	33	**B. Estimations using sintered crucible**	5
		Magnesium as oxinate	
		Nickel as nickel dimethyl glyoximate	
		Copper as copper thiocyanate	
		Silver as silver chloride	
	34	**C. Colorimetry**	5
		Determination of Fe^{3+} using thiocyanate	
		Determination of ammonia using Nessler's reagent.	

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1. B.R. Puri L.R. Sharma, K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.
3. R. Gopalan, V.Ramalingam, *Concise Coordination Chemistry*, 1st Edn.,Vikas Publishing House, New Delhi, 2001.
4. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, 5th Edn., Vol. I, S Chand, 2012.
5. S. Manku, *Theoretical Principles of Inorganic Chemistry*. McGraw-Hill Education; New edition (1 August 1982)
6. M.C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.
7. J. E. Huheey, E.A. Keitler, R. L. Keitler, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi,2013.
8. B.K. Sharma, *Industrial chemistry*, 11th Edn., Goel publishing House, Meerut, 2000.
9. M.N. Greenwood, A. Earnshaw, *Chemistry of elements*, 2nd Edn., Butterworth,1997.
10. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.
11. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.

Further Reading

1. James E. House, Inorganic Chemistry, academic press, 2008.
2. W.U. Malik, G.D.Tuli, R.D. Madan, selected Topics in Inorganic Chemistry, S. Chand and Co., New Delhi, 2010.
3. F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., Wiley India Pvt. Ltd., New Delhi,2009.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the electronic configuration, general properties, and reactions of lanthanides and actinides, including their unique properties and applications	R, U	PSO-1,2,3
CO-2	Understand the principles and theories in coordination chemistry, including ligand classification, nomenclature of complexes, and factors influencing the stability of complexes.	R. U	PSO-1,2,3
CO-3	Gain proficiency in applying various theoretical models to analyze and predict the properties of coordination compounds, including their magnetic behaviour, colour, and stability.	U, An	PSO-1,2,3
CO-4	Gain insights into the applications of organometallic compounds in various fields such as catalysis, materials science, and bioinorganic chemistry.	An, Ap	PSO-1,2,3,5
CO-5	Gain insight into the metallurgy of specific metals, enabling to comprehend the practical aspects of metallurgical processes and their applications in industry.	An, Ap	PSO-1,2,3
CO-6	Develop skills in quantitative analysis, data interpretation, and laboratory techniques, enabling them to apply these methods effectively in practical scenarios and contribute to advancements in analytical chemistry.	Ap, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INORGANIC CHEMISTRY III A

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	R. U	F, C	L	-

3	CO-3	PO-1,6 PSO-1,2,3	U, An	C	L	-
4	CO-4	PO-1,2,6 PSO-1,2,3,5	An, Ap	C	L	-
5	CO-5	PO-1,6 PSO-1,2,3	An, Ap	C	L	-
6	CO-6	PO-1,2,3,6 PSO-1,2,3,4,5	Ap, E	P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	3	3	2	-	-	2					3		
CO 2	3	3	2	-	-	2					3		
CO 3	3	3	2	-	-	2					3		
CO 4	2	3	2	-	2	2	1				3		
CO 5	3	3	2	-	-	2					2		
CO 6	3	2	2	2	2	2	1	1			2		

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSCCHE301**				
Course Title	**MATERIAL CHEMISTRY**				
Type of Course	**DSC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. UK1DSCCHE100 2. UK4DSCCHE200				
Course Summary	Explores the structures, symmetries, and properties of solids, understanding factors like coordination numbers, lattice energies, and defects. Inorganic solids and silica-based materials offer a wide array of synthesis methods and applications, from solid electrolytes to nanomaterials and composites, each contributing to diverse fields such as catalysis, electronics, and materials science. A comprehensive understanding of crystalline solids, inorganic materials, nanomaterials, and composites, exploring their structures, properties, synthesis methods, and applications across various disciplines is expected.				

Detailed Syllabus:

Module	Unit	Content MATERIAL CHEMISTRY	Hrs 75
I	**BASICS OF CRYSTALLINE SOLIDS**		**9**
	1	Crystalline solids, crystal systems, Bravais lattices, coordination number, packing fraction – cubic, hexagonal, diamond structures, lattice planes	3
	2	Miller indices, interplanar distances, directions, types of bonding, lattice energy, Madelung constants, Born Haber cycle, cohesive energy	3
	3	Symmetry elements, operations, translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals - Kroger Vink notation of defects, polymorphism, twinning.	3
II	**INORGANIC SOLIDS & SILICA BASED MATERIALS**		**18**
	4	Preparation of inorganic solids: Conventional heat and beat methods, co-precipitation method, sol-gel methods, hydro-thermal method, ion-exchange and intercalation methods, template assist method, solvothermal method, spray pyrolysis and spray calcination methods.	4

	5	Materials characterisations using: Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy AFM, Dynamic light scattering (DLS)	3
	6	Spectroscopic techniques: XRD, IR spectroscopy for surface functionalization of materials, UV-visible - Diffused reflectance spectroscopy and optical band gap, photoluminescence, Raman spectroscopy. (Basic understanding of each technique)	2
	7	Silica based materials: Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials:	5
	8	Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications	4
III	**NANOMATERIALS**		**9**
	9	Overview of nanostructures and nano-materials - Characteristics of Nanomaterials: Surface area to volume ratio and its significance - Novel properties of Nanomaterials: Size dependent optical (surface plasmon resonance), electronic, mechanical, magnetic and catalytic properties	3
	10	Bottom up and top-down approach of nanoparticles synthesis, nucleation and growth of nanoparticles, preparation of gold and silver metallic nanoparticles, semiconductor nanoparticles (CdS and CdSe nanoparticles) - metal oxide nanoparticles (zinc oxide, iron oxide, silica and titania nanoparticles) - Nanocomposites – Nanoceramics (Definition with examples)	3
	11	Self-assembled nanostructures-control of nano-architecture-one dimensional control. Carbon Based Nanomaterials: Graphene, Carbon Nanotubes, Fullerenes, Carbon dots	3
IV	**COMPOSITE MATERIALS**		**9**
	12	Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements	5
	13	metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.	4
V	**PRACTICALS: GRAVIMETRIC ANALYSIS**		**30**
		A minimum of 5 practical experiments from any sections must be performed and reported.	
	14	**A. Estimations using silica crucible**	20
		Estimation of water of crystallization in hydrated Bariumchloride	
		Estimation of Barium as Barium sulphate	
		Estimation of sulphate as Barium sulphate	
		Estimation Iron as Fe_2O_3	
		Estimation Calcium as $CaCO_3$	
		Estimation Aluminium as Al_2O_3	
		Estimation Magnesium as $Mg_2P_2O_7$	
	15	**B. Estimations using sintered crucible**	6
		Magnesium as oxinate	

		Nickel as nickel dimethyl glyoximate	
		Copper as copper thiocyanate	
		Silver as silver chloride	
	16	**C. Colorimetry**	4
		Determination of Fe^{3+} using thiocyanate	
		Determination of ammonia using Nessler's reagent.	

References:

1. Atkins P, Overton T., Rourke J. Weller M. and Armstrong F Shriver and Atkins. *Inorganic Chemistry* Oxford University Press, Fifth Edition, 2012.
2. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. John Wiley,1974.
3. Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley 2003.
4. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning, 2002.
5. C.N.R., Rao, A. Müller, and A.K. Cheentham, (Eds.), "*Chemistry of Nanomaterials*", Wiley – VCH. 2005
6. T., Pradeep, *A Textbook of Nanoscience and Nanotechnology*, Mc Grawhill, New Delhi, 2012.
7. M. A. Shah, Tokeer Ahmad, *Principles of Nanoscience and Nanotechnology*, Narosa Publishing House, New Delhi, 2010.
8. V. S. Muralidharan, A. Subramania, *Nano Science and Technology*, CRC Press, London.
9. M.J. Starfield and Shrager, *Introductory Material Science*, McGraw Hill.
10. K.K. Chowla, *Composite Materials*, Springer – Verlag, NY,1987.
11. M. Tinkham, *Introduction to Superconductivity*, McGraw Hill, 1975.
12. A.V. Narlikar and S.N. Edbote, *Superconductivity and Superconducting Materials*, South Asian Publishers, New Delhi, 1983.
13. *Vogel's Text Book of Quantitative Chemical Analysis*, J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas, Pearson Education.
14. *Analytical Chemistry*, R. Gopalan, S. Chand and Co., New Delhi.
15. *Quantitative Analysis*, R. A. Day Junior, A.L. Underwood, 5th edn. Prentice Hall of India Pvt. Ltd. New Delhi.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explore the fundamentals of crystallography, crystal systems their packing in the lattice.	R, U	PSO-1,2,3
CO-2	Explore emerging topics such as solid electrolytes, inorganic liquid crystals, ionic liquids, silica-based materials and hybrid organic-inorganic materials	U, An	PSO-1,2,3
CO-3	Equip with the knowledge and skills for designing and	An, Ap	PSO-

	engineering functional materials for energy storage, catalysis, and nanotechnology.		1,2,3,5
CO-4	Provide an understanding of the synthesis, properties, and applications of nanomaterials, with a focus on manipulating their nanostructure for specific functionalities.	Ap, E	PSO-1,2,3,5
CO-5	Understand the principles of composite materials, their classifications, manufacturing processes, properties, and applications	R, U	PSO-1,2,3
CO-6	Hands-on experience in gravimetric analysis to accurately determine the quantity of a substance through precipitation and subsequent measurement techniques, fostering a deeper understanding of quantitative analytical methods in chemistry.	An, Ap	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: MATERIAL CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	U, An	F, C	L	-
3	CO-3	PO-1,2,3,6 PSO-1,2,3,5	An, Ap	C, M	L	-
4	CO-4	PO-1,2,3,6 PSO-1,2,3,5	Ap, E	C, M	L	-
5	CO-5	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
6	CO-6	PO-1,2,3,6 PSO-1,2,3,4,5	An, Ap	P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	2	-	-	-	-	2	-	-
CO 2	3	3	2	-	-	2	1	-	-	-	2	-	-
CO 3	3	3	3	-	2	1	2	2	-	-	2	-	-
CO 4	3	3	3	-	2	1	2	2	-	-	2	-	-
CO 5	3	3	2	-	-	2	1	2	-	-	2	-	-
CO 6	3	3	2	2	2	2	2	2	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSCCHE302**				
Course Title	**PHYSICAL CHEMISTRY II**				
Type of Course	**DSC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Essential conditions for understanding quantum mechanics, spectroscopy, statistical thermodynamics and group theory include a strong grasp of fundamental principles such as wave-particle duality, electromagnetic radiation interactions, statistical ensembles and symmetry operations. 2. Proficiency in mathematical techniques, experimental methodologies, data interpretation, and their applications in various scientific disciplines is crucial for mastering these subjects.				
Course Summary	This course provides a comprehensive understanding of Quantum Mechanics, delving into wave-particle duality, Schrödinger's equation, and energy quantization. Spectroscopy techniques, including rotational spectroscopy, vibrational spectroscopy, electronic spectroscopy, Raman NMR and ESR, are explored for molecular analysis and structural elucidation. Additionally, students study Statistical Thermodynamics and Group Theory for molecular symmetry analysis.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**QUANTUM MECHANICS**		**12**
	1	Formulation of quantum mechanics: The wave nature of sub-atomic particles. de Broglie relation and its experimental proof. The uncertainty principle and its consequences. The postulates of quantum mechanics. Concept of operators: Laplacian, Hamiltonian, linear and Hermitian operators.	5
	2	Eigen function and eigen values. Physical interpretation of wave function. Boundary conditions and well-behaved functions. Applications of quantum mechanics to simple systems: Solutions of Schrodinger wave equations for a particle in 1D box and particle in 3D box. Harmonic oscillator (No Derivation).	4

	3	Atomic Spectra: Space quantization. Spin of electron. Spin orbit coupling. The exclusion principle.	3
II	**SPECTROSCOPY I**		**12**
	4	Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.	4
	5	Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches	4
	6	Raman spectroscopy: Quantum theory of Raman effect, Rotational Raman spectrum, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.	4
III	**SPECTROSCOPY II**		**12**
	7	Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.	3
	8	NMR spectroscopy: Principle of NMR, nuclear spin. HNMR, Interaction of nuclear spin with external magnet. Energy level splitting, Precession.	2
	9	Chemical shift. Delta and tau scales. Presentation of NMR spectra, Low and high-resolution spectra of simple molecules like ethanol, 2-chloropropane etc, Spin-spin coupling	2
	10	Electron spin resonance spectroscopy: Principle, Types of substances with unpaired electrons, interaction of electron magnet with external magnet.	2
	11	Energy level splitting. Lande splitting factor, presentation of ESR spectrum, the normal and derivative spectra. Hyperfine splitting. Simple examples of methyl and benzene radicals	3
IV	**STATISTICAL THERMODYNAMICS & GROUP THEORY**		**12**
	12	Statistical thermodynamics: introduction, types of statistics-MB, BE and FD. Fermions and bosons, Phase space, system, assembly and ensemble-types of ensembles and uses. Thermodynamic probability, Boltzmann distribution law (no derivation). Partition function, molecular partition function for ideal gas	3
	13	Thermodynamic functions in terms of partition functions -internal energy, enthalpy, pressure, work function and free energy function	2
	14	Symmetry element and operation, definition of mathematical group, sub group, cyclic group, conjugacy relation and classes, point symmetry group (Schonflies symbols), use of point group symmetry: optical activity, dipole moment, representation of group by matrices, character of representation,	4
	15	The great orthogonality theorem (without proof) and its importance, irreducible representation, character table and their use. Construction of Group multiplication table of C_2V.	3

V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions on real life applications, assignment discussions, Quizzes, Open book exams, etc on the above four modules.**	**12**

References:

1. Ira N. Levine, *Quantum Chemistry*, Delhi: PHI Learning, 2014.
2. R L Madan, *Quantum Mechanics and Analytical Techniques*, NEP 2020 Uttar Pradesh Latest Edition 2023 By S. Chand's.
3. *A Text book of Quantum Mechanics*, PM Mathews & K Venkatesan, 2nded, Tata McGraw Hill, (2011).
4. *Introduction to Quantum Mechanics*, David Griffiths, 2nded., Pearson, (2015).
5. C.N. Banwell, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill Education.
6. Manas Chanda, "*Atomic structure and Chemical bonding in Molecular Spectroscopy*", Tata McGraw Hill.
7. A. Salahuddin Kunju and G. Krishnan, *Group Theory and its Applications in Chemistry*, PHI Learning Pvt. Ltd.
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10. J. E. Huheey,E. A. Keiter, R. L. Keiter, O. K. Medhi. *Inorganic Chemistry*, 4th Edn. Pearson, 2006.
11. D. A. Skoog, F. James Holler. S.R. Crouch. *Principles of Instrumental analysis*, 6th Edn., Cengage Learning, Noida, 2004.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamental principles of quantum mechanics, and apply to explain the behaviour of particles at the atomic and molecular levels.	R, U	PSO-1,2,3
CO-2	Apply spectroscopic methods to investigate the properties of molecules and determine the molecular structures by interpreting spectra.	An, Ap	PSO-1,2,3
CO-3	Apply statistical thermodynamics to predict thermodynamic properties of systems and understand chemical equilibria.	Ap, E	PSO-1,2,3,5
CO-4	Understand the mathematical principles of group theory and its applications in chemistry and apply to predict molecular properties and interpret spectroscopic data.	Ap, E	PSO-1,2,3,5

CO-5	Foster critical thinking, problem-solving, and collaborative skills essential for advanced studies and research in chemistry.	E, C	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHYSICAL CHEMISTRY II

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R, U	F, C	L	-
2	CO-2	PO-1,2,3,6 PSO-1,2,3	An, Ap	C, P	L	-
3	CO-3	PO-1,2,3,6 PSO-1,2,3,5	Ap, E	C, P	L	-
4	CO-4	PO-1,2,3,6 PSO-1,2,3,5	Ap, E	C, P	L	-
5	CO-5	PO-1,2,3,4,5,6 PSO-1,2,3,4,5	E, C	M	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	-	-	2	-	-	-	-	3	-	-
CO 2	3	3	3	-	-	3	2	2	-	-	3	-	-
CO 3	3	3	3	-	2	3	2	2	-	-	2	-	-
CO 4	3	3	3	-	2	3	2	2	-	-	2	-	-
CO 5	2	2	3	2	3	3	3	3	2	2	3	-	-

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5	✓	✓	✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSCCHE303**				
Course Title	**THEORETICAL CHEMISTRY I**				
Type of Course	**DSC**				
Semester	5				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Idea about early atom models – John Dalton's atomic theory, discharge tube experiment and discovery of electron, the plum-pudding model, the gold foil experiment and the invention of the nucleus, Rutherford's nuclear model of the atom, failures of the nuclear model. 2. Mathematical prerequisites - basic understanding of differentiation, partial differentiation, integration, technique of separation of variables. Cartesian and spherical polar coordinate systems.				
Course Summary	The behaviour and various bulk properties of matter can be explained through thermodynamics. The individual behaviour of atoms and molecules influences the bulk properties of matter. Quantum mechanics is mainly related to the properties of the micro-world. The course introduces the basic principles of quantum mechanics and explains how quantum mechanics has revolutionized our understanding of atomic structure and chemical bonding.				

Detailed Syllabus:

Module	Unit	Content THEORETICAL CHEMISTRY I	60 Hrs
I	**DAWN OF QUANTUM THEORY**		**9**
	1.1	Review on experiments which led to the development and generalization of quantum theory – black body radiation, Planck's quantum hypothesis, Photoelectric effect, Einstein's generalization of quantum theory.	**3**
	1.2	Atomic models based on quantum theory – Bohr's theory of the atom, calculation of Bohr radius, velocity and energy of an electron.	**2**
	1.3	Atomic spectra of hydrogen and hydrogen like atoms. Origin of different series of lines of hydrogen spectrum using Bohr's theory. Limitations of Bohr's theory	**2**

	1.4	Louis de Broglie's matter waves –wave-particle duality– de Broglie equation. Dual nature of electrons–Electron diffraction–Davisson and Germer experiment.	**2**
II	**INTRODUCTORY QUANTUM CHEMISTRY**		**9**
	2.1	Heisenberg's uncertainty principle and the need of quantum mechanics	**1**
	2.2	Schrodinger wave equation. Operators–algebra of operators. Types of operators–Linear, Hermitian, Laplacian and Hamiltonian operators. Eigen value and eigen function of an operator.	**2**
	2.3	Physical significance of wave function Ψ, well behaved function. The Born interpretation of the wave function and probability density. Normalization of wave function–orthogonality and orthonormality.	**2**
	2.4	Postulates of quantum mechanics–Wave function postulate–Time-dependent Schrodinger equation postulate–Operator postulate–Eigen value postulate–Average value or expectation value postulate.	**4**
III	**APPLICATIONS OF TIME INDEPENDENT SCHRÖDINGER WAVE EQUATION**		**12**
	3.1	Particle in a one-dimensional box with infinite potential energy walls – Derivation of wave functions and energy, normalization of wave function, plots of wave functions and probability densities. Calculation of energy levels and absorption band in butadiene using the particle in a box model.	4
	3.2	Particle in a three-dimensional box – separation of variables and derivation of wave functions and energy, degeneracy of states in a cubic box.	2
	3.3	Application of Schrodinger wave equation to hydrogen atom (no derivation) Schrodinger wave equation in Cartesian and spherical polar co-ordinates. Separation of variables (qualitative idea only).	2
	3.4	Concept of atomic orbitals. Quantum numbers (n, l, m)–spin quantum number.	1
	3.5	Radial and angular functions. Radial distribution curves. Angular dependence of the wave function – Angular distribution plots and shapes of orbitals. Electron arrangement in atoms–Aufbau principle, Hund's rule and Pauli's exclusion principle.	2
	3.6	Need for approximation methods in multi electron systems.	1
IV	**BONDING IN DIATOMIC AND POLYATOMIC MOLECULES**		**18**
	4.1	Hamiltonian operator of H_2 molecule – Born-Oppenheimer approximation. Variation theorem.	2
	4.2	Valence bond theory of H_2 molecule - trial wave function, improvements by including delocalisation of electrons, mutual screening and partial ionic character. Potential energy profile of H_2 molecule formation - equilibrium geometry, Comparison of theoretical and experimental energy profiles.	3
	4.3	Molecular orbital theory–linear combination of atomic orbitals (LCAO), bonding and anti-bonding molecular orbitals, wave function as product of one electron functions, electron distribution in bonding	2

		and anti-bonding molecular orbitals, overlap integral, Coulomb integral. Molecular orbital theory of H_2^+ ion (qualitative idea only)	
	4.4	MO diagrams of homonuclear diatomic molecules – He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2; Bond order, stability and magnetic properties of these molecules.	2
	4.5	MO diagrams of heteronuclear diatomic molecules - CO and NO Bond order.	1
	4.6	Comparison of VB and MO theories.	1
	4.7	Concept of Hybridization: Definition, need of hybridization.	1
	4.8	LCAO of the central atom – coefficients of atomic orbitals in the linear combination of sp (BeH_2), sp^2 (BH_3) and sp^3 (CH_4) hybridization (derivation not required).	4
	4.9	Application of hybridization concept–geometry of molecules like PCl_5, SF_6 and IF_7.	2
V	**OPEN ENDED MODULE: LEARNING THROUGH PROBLEM SOLVING AND PLOTS**		**12**
	5.1	Excel: graphing the 1D particle in a box wavefunctions	
	5.2	Plots of angular parts of atomic orbitals using any freeware	
	5.3	Solving problems	
	5.4	Connections with conjugated organic molecules	

Books and References:

1. D. A. McQuarrie, *Quantum Chemistry*,Viva, 2016.
2. I. N. Levine, *Quantum Chemistry*, 6th Edn., Pearson Education Inc., 2009.
3. R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.
4. James E. Huheey, Ellan A. Keiter, Richard L. Keiter, *Inorganic Chemistry – Principles of Structure and Reactivity*, 4th Edn., Harper Collins, 1993.
5. D. A. McQuarrie, J. D. Simon, *Physical Chemistry – A Molecular Approach*, Viva, 2001.
6. M.C. Day, J Selbin, *Theoretical inorganic chemistry*. 2nd Edition, 2008.

<u>**Course Outcomes**</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	*recognize* the importance and the impact of quantum mechanics in the revolution in science.	R	PSO-1,2,3
CO-2	*identify* the wave functions of hydrogen atom as atomic orbitals.	R, U	PSO-1,2,3
CO-3	*apply* the concept of atomic orbitals in chemical bonding (the mixing of wave functions of the two	Ap	PSO-1,2,3,5

	combining atoms).		
CO-4	*relate* the concept of hybridization as linear combination of atomic orbitals of the same atom.	An	PSO-1,2,3,5
CO-5	*instil* an atomic/molecular level philosophy in the minds of the students.	C	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: THEORITICAL CHEMISTRY I

Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R	F	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	U	C	T	-
3	CO-3	PO-1,2,6 PSO-1,2,3,5	Ap	C	T	-
4	CO-4	PO-1,2,3,6 PSO-1,2,3,5	An	P	L/T	-
5	CO-5	PO-1,2,3,6 PSO-1,2,3,4,5	C	M	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	-	-	1	-	-	-	-	3	-	-
CO 2	3	3	3	-	-	2	1	-	-	-	3	-	-
CO 3	3	3	3	-	2	2	1	-	-	-	3	-	-
CO 4	3	3	3	-	2	2	1	1	-	-	3	-	-
CO 5	3	3	3	1	2	3	3	3	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5			✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSCCHE304**				
Course Title	**ORGANIC CHEMISTRY III**				
Type of Course	**DSC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. UK2DSCCHE100 2. UK4DSCCHE202				
Course Summary	The organic chemistry curriculum covers a wide array of topics, including alcohols, phenols, ethers, epoxides, aldehydes, ketones, carboxylic acids, and their derivatives, as well as carbohydrates and organometallic compounds. Students learn about preparation methods, chemical properties, and reactions of these compounds, providing a comprehensive understanding of organic chemistry principles and their applications in various fields such as biofuels, pharmaceuticals, and materials science.				

Detailed Syllabus:

Module	Unit	Content ORGANIC CHEMISTRY III	60 Hrs
I	**ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES**		**12**
	1	Alcohols: Preparation- From alkenes (hydration, hydroboration oxidation, oxy-mercuration-demercuration) and carbonyl compounds (reduction and with Grignard reagent)	2
	2	Chemical properties: Reactions involving cleavage of O-H, bonds (acidity and esterification), oxidation (with PCC, Collins reagent, Jones reagent and $K_2Cr_2O_7$) and catalytic dehydrogenation	1
	3	Distinction between primary, secondary and tertiary alcohols. Biofuel – ethanol and biodiesel	2
	4	Dihydric alcohols: Oxidative cleavage – Lead tetra acetate, periodic acid – Pinacol-pinacolone rearrangement (mechanism expected)	1
	5	Phenols: Preparation from halobenzenes, cumene and sulphonic acid. Chemical properties: – bromination, nitration, sulphonation	2

	6	Reimer-Tiemann reaction (mechanism expected), Kolbe reaction, Liebermann's nitroso reaction, distinction between alcohols and phenols.	2
	7	Ethers: Preparation by Williamson's synthesis, reactions of ethers: Cleavage by HI– Ziesel's method of estimation of methoxy group Epoxides – preparation from halohydrins, reaction with nucleophiles- RMgX, OH-, conversion to carbonyl compounds in the presence of Lewis acid	2
II	**ALDEHYDES AND KETONES**		**12**
	8	Addition-elimination reaction (with ammonia and ammonia derivatives). Addition reactions of unsaturated carbonyl compounds: Michael addition. Reduction using Metal hydrides (mechanism expected), MPV reduction, Clemmenson and Wolff-Kishner reduction	3
	9	Preparation: Oxidation of primary and secondary alcohols using PCC, reduction of esters using DIBAL-H, Rosenmund reduction, Gattermann-Koch formylation. Chemical properties: Nucleophilic addition (HCN, NaHSO3, RMgX and ROH)	3
	10	Oxidation: with KMnO4, Tollen's reagent, Fehling solution, Baeyer-Villiger oxidation	2
	11	Acidity of α-hydrogen: Aldol, Claisen-Schmidt, Benzoin, Perkin and Knovenagel condensations (mechanism not expected).	2
	12	Haloform reaction – Iodoform test – Cannizaro reaction (mechanism not expected) and Beckmann rearrangement (mechanism not expected).	2
III	**CARBOXYLIC ACIDS, SULPHONIC ACID AND THEIR DERIVATIVES**		**12**
	13	Preparation: Hydrolysis of nitrile, carboxylation of Grignard reagent	3
	14	Chemical properties: HVZ reaction, Decarboxylation – Kolbe electrolysis (Mechanism expected), Curtis reaction. Ascent and descent series in aliphatic carboxylic acids	3
	15	Preparation, properties and uses of anthranilic acid, cinnamic acid and phthalic acid.	2
	16	Carboxylic acid derivatives - Preparation of acid chlorides, amides, acid anhydrides and esters – comparison of reactivity	2
	17	Preparation and reactions of benzene sulphonic acid, toluene sulphonic acid– Importance of tosyl group – synthesis and application of saccharin.	2
IV	**CARBOHYDRATES**		**12**
	18	Classification and nomenclature of carbohydrates, configuration of monosaccharides.	3
	19	Reactions of glucose and fructose – Determination of open chain structure of D-glucose and D-fructose.	3

	20	Anomers and mutarotation in glucose - cyclic structure – pyranose and furanose forms – Haworth projection formula – chair conformations. Epimers and epimerization – Interconversion of aldoses and ketoses – chain lengthening and shortening of aldoses.	3
	21	Disaccharides – reactions and structure of sucrose -Polysaccharides – Structure of starch and cellulose (structural elucidation not required) – Industrial applications of cellulose-Paper Industry, Textile Industry, Rayon.	3
V	**ORGANOMETALLICS AND ACTIVE METHYLENE COMPOUNDS (Open ended module- This portion can be substituted by any other topics as selected by the teacher and can be evaluated by any method of teacher's choice)**		**12**
	22	Organomagnesium compounds: Grignard reagent: Preparation – Reaction with compounds containing acidic hydrogen, carbonyl compounds, cyanides and CO2.	3
	23	Organo lithium compounds: Preparation – Reaction with compounds containing acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO2.	3
	24	Organo zinc compounds: Preparation of dialkyl zinc – Reaction with active hydrogen compounds, acid halides and alkyl halides,Reformatsky reaction (mechanism expected)	2
	25	Li dialkylcuprates – preparation, reaction with alkyl/vinyl/allyl/acyl halides, 1,2 and 1,4-addition to carbonyl compounds	2
	26	Active methylene compounds – examples. Preparation of ethyl acetoacetate by Claisen condensation (mechanism expected), tautomerism, Synthetic applications of acetoacetic ester.	2

References

Text books

1. A.Bahl and B.S.Bahl, Advanced Organic Chemistry, S.Chand& Company, New Delhi.
2. L.G.Wade Jr, Organic Chemistry, Pearson Education, New Delhi.
3. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, A textbook of Organic Chemisty, Vikas Publishing House (Pvt) Ltd., New Delhi..
4. S.C.Sharma and M.K.Jain, Modern Organic Chemistry, Vishal Publishing Company, New Delhi.
5. I L Finar, "Organic Chemistry" Vol – 1, 5th Edition, Pearson Education, New Delhi.
6. J. Clayden, N.Greeves and S.Warren, Organic Chemistry, Oxford University Press, New York..

For further reading:

1. R.T.Morrison, R.N.Boyd. Organic Chemistry, Pearson Education, New Delhi.
2. P.Y.Bruice, Essential Organic Chemisty, Pearson Education, New Delhi.

3. G.M. Louden, Organic Chemistry, Oxford University Press, New York.
4. V.K.Ahluwaliya, Organic Reaction Mechanisms, Narosa Publishing House, New Delhi.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the chemistry of alcohols, phenols, ethers and epoxides.	U	PSO-1,2,3,4
CO-2	Describe various preparation methods and chemical reactions of carbonyl compounds	R, U	PSO-1,2
CO-3	Understand the importance of chemistry of carboxylic acids, sulphonic acids and their derivatives.	U,An	PSO-1,2
CO-4	Analyse the structure of glucose, fructose, sucrose, starch and cellulose and steps involved in the interconversion of monosaccharides.	Ap, An	PSO-1,2
CO-5	Discuss synthesis and reactions of organo Mg. Li, Zn, Cu and active methylene compounds.	Ap, An	PSO-1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ORGANIC CHEMISTRY III

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,2,3,4	U	F	L	-
2	CO-2	PSO-1,2	R, U	F	L	-
3	CO-3	PSO-1,2	U, An	C	L	-
4	CO-4	PSO-1,2	Ap, An	F, C	L	-
5	CO-5	PSO-1,2,4,5	U, Ap, C	P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	2	2	-	-	-	-	-	-
CO 3	1	-	-	-	-	2	2	-	-	-	-	-	-
CO 4	2	3	3	-	-	2	2	-	-	-	-	-	-
CO 5	2	3	-	-	2	2	2	3	-	-	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5	✓	✓	✓	-

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSCCHE305**				
Course Title	**INORGANIC CHEMISTRY IIIB**				
Type of Course	**DSC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. UK1DSCCHE100 2. UK4DSCCHE200				
Course Summary	The course covers topics including the chemistry of Boron, Sulphur, Phosphorus, Nitrogen compounds, Metal Clusters and Cages, Bioinorganic Chemistry, and Spectral Methods in Inorganic Chemistry. Students will gain theoretical knowledge in these areas, enabling to understand the structure, properties, and applications of diverse inorganic compounds and materials, as well as the spectroscopic techniques used for their characterization. Through a combination of lectures, laboratory experiments, and open-ended learning modules, develop a deep understanding of the principles and applications of inorganic chemistry in various fields.				

Detailed Syllabus:

Module	Unit	Content INORGANIC CHEMISTRY IIIB	Hrs 60
I	**B, S, P AND N COMPOUNDS**		**12**
	1	Sulfur-Nitrogen Compounds - Introduction to sulfur-nitrogen compounds - Detailed study of S_4N_4, S_2N_2, S_4N_2, and polythiazyl compounds - Discussion on S-N cations and anions	2
	2	Sulfur-Phosphorus Compounds - Overview of molecular sulphides such as P_4S_3, P_4S_7, P_4S_9, and P_4S_{10} - Properties and reactions of sulfur-phosphorus compounds	2
	3	Phosphorus-Nitrogen Compounds - Introduction to phosphazines - Discussion on cyclo and linear phosphazines - Properties and applications of phosphorus-nitrogen compounds	2
	4	Boron-Nitrogen Compounds	2

		-Detailed study of boron-nitrogen compounds including borazine, substituted borazines, and boron nitride - Properties, reactions, and applications of boron-nitrogen compounds	
	5	Boron Hydrides - Overview of boron hydrides, focusing on diborane (B_2H_6) - Explanation of structure and bonding in diborane -Introduction to polyhedral boranes, their preparation, properties, structure, and bonding	2
	6	Topological Approach to Boron Hydride Structure - Explanation of the topological approach to boron hydride structure - Introduction to Styx numbers and their significance - Importance of icosahedral framework of boron atoms in boron chemistry - Discussion on closo, nido, and arachno structures and Wade's rules	1
	7	Carboranes and Metallocarboranes - Overview of carboranes and metallocarboranes - Properties and applications of carboranes and metallocarboranes - Discussion on synthetic methods and structural features of these compounds	1
II	**METAL CLUSTERS AND CAGES**		**12**
	1	Metal–Metal Bonds and Conditions for formation - Introduction to metal–metal bonds - Favourable conditions for the formation of metal–metal bonds	2
	2	Compounds with Metal–Metal Multiple Bonds - Compounds with metal–metal multiple bonds - Examples of dinuclear compounds of Re, Cu, and Cr - Exploration of metal-metal multiple bonding in complexes such as $(Re_2X_8)^{2-}$	2
	3	Metal Atom Clusters: Tri, Tetra, and Hexa Nuclear Clusters - Overview of metal atom clusters - Introduction to tri-, tetra-, and hexa-nuclear clusters - Explanation of isoelectronic and isolobal relationships in metal clusters	2
	4	Low Nuclearity and High Nuclearity Carbonyl Clusters (LNCCs and HNCCs) - Detailed study of low nuclearity and high nuclearity carbonyl clusters - Properties and examples of LNCCs and HNCCs - Electron counting schemes for high nuclearity carbonyl clusters, including the capping rule	2
	5	Heteroatoms in Metal Atom Clusters - Discussion on the inclusion of heteroatoms in metal atom clusters - Explanation of electron counting schemes for HNCCs, considering the capping rule - Exploration of the significance of heteroatoms in cluster stability and reactivity	2
	6	Molecular Clusters in Catalysis and Applications - Overview of molecular clusters in catalysis	2

		- Explanation of the role of metal atom clusters as catalysts in various reactions - Examples illustrating the use of metal atom clusters in catalytic processes - Discussion on the potential applications and future prospects of molecular clusters in catalysis	
III	**BIOINORGANIC CHEMISTRY**		**12**
		Elements present in biological system- essential and non-essential elements - Metal ions in biological system – Trace and bulk metal ions.	2
		Role of alkali metal ions in biological systems - Sodium-potassium pump– Structural role of calcium.	1
		Structure of heme - Oxygen transport by heme proteins-hemoglobin and myoglobin-structure of the oxygen binding site-nature of hemedioxygen binding, cooperativity.	2
		Ligands present in biological systems- structure of Porphyrin and Corrin	2
		Structure of Hemerythrin and hemocyanin	1
		Metallo enzymes and metal activated enzymes - Biochemistry of Zn – structure and functions of Carboxypeptidase, carbonic anhydrase- Biochemistry of Cobalt - Vitamin B 12 and deficiency diseases	2
		Chlorophyll and photosynthesis (no mechanism)	1
		Anticancer drugs. Cis-platin, oxaliplatin, carboplatin and auranofin – Structure and significance.	1
IV	**SPECTRAL METHODS IN INORGANIC CHEMISTRY**		**12**
	1	Introduction to Spectroscopy in Inorganic Chemistry - Overview of spectroscopic techniques: UV-Vis, IR, NMR, EPR, X-ray, and mass spectrometry - Importance of spectroscopy in studying inorganic compounds - Basic principles of spectroscopy: absorption, emission, scattering, and detection.	2
	2	UV-Visible Spectroscopy - Principles of UV-Vis spectroscopy - Electronic transitions in inorganic compounds - Determination of electronic structure, coordination geometry, and ligand field effects - Applications in transition metal complexes and metal-ligand bonding studies	2
	3	Infrared (IR) Spectroscopy - Principles of IR spectroscopy - Vibrational modes in inorganic compounds - Identification of functional groups, coordination modes, and ligand types - Applications in characterizing metal complexes, organometallic compounds, and coordination polymers	2
	4	Nuclear Magnetic Resonance (NMR) Spectroscopy - Principles of NMR spectroscopy - Chemical shift, spin-spin coupling, and relaxation processes - Applications in determining coordination environment, ligand binding, and dynamics of metal complexes	2

		- Introduction to multinuclear NMR techniques for studying diverse nuclei (e.g., 1H, 13C, 31P)	
	5	Electron Paramagnetic Resonance (EPR) Spectroscopy - Principles of EPR spectroscopy - Spin Hamiltonian and energy-level diagrams - Applications in studying paramagnetic species, metalloenzymes, and magnetic materials - Introduction to advanced EPR techniques (e.g., ENDOR, ESEEM).	2
	6	Advanced Topics and Applications - X-ray Crystallography: Principles and applications in determining molecular structure and crystal packing - Mass Spectrometry: Principles and applications in studying the composition, fragmentation, and reactivity of inorganic compounds - Combined Spectroscopic Techniques: Case studies and examples of using multiple spectroscopic methods for comprehensive characterization - Emerging trends and future directions in spectroscopic methods for inorganic chemistry	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
	23	5. Impact of phosphorus-based fertilizers for agricultural practices. 6. Role of phosphorus compounds in living systems, such as DNA and ATP. 7. Applications of boranes in organic synthesis 8. Importance of nitrogen-containing heterocycles for pharmaceutical applications 9. Catalytic properties of metal clusters in various chemical reactions. 10. Metal-organic frameworks (MOFs) and their applications in gas storage. 11. Role of metal ions in enzyme catalysis and metalloprotein function. 12. Metal complexes for biomedical applications - cancer treatment/imaging agents. 13. Metal ion transport and homeostasis in biological systems 14. Analyzing some model spectra of inorganic complexes to determine the coordination geometries and ligand types. 15. Any similar learning methods suggested by the faculty based on I-IV modules. **(Or any other related activities introduced by the teacher)**	

References:

1. B.R. Puri L.R. Sharma, K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.
3. R. Gopalan, V.Ramalingam, *Concise Coordination Chemistry*, 1^{st} Edn.,Vikas Publishing House, New Delhi, 2001.

4. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, 5th Edn., Vol. I, S Chand, 2012.
5. J. E. Huheey, E.A. Keitler, R. L. Keitler, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi,2013.
6. M.N. Greenwood, A. Earnshaw, *Chemistry of elements*, 2nd Edn., Butterworth,1997.

Further Reading

1. James E. House, *Inorganic Chemistry*, academic press, 2008.
2. W.U. Malik, G. D.Tuli, R.D. Madan, S*elected Topics in Inorganic Chemistry*, S. Chand and Co., New Delhi, 2010.
3. F.A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley India Pvt. Ltd., New Delhi,2009.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the structure and chemical behaviour of sulfur-nitrogen, sulfur-phosphorus, phosphorus-nitrogen, and boron-nitrogen compounds, their synthesis, properties, and reactions.	R, U	PSO-1,2
CO-2	Demonstrate knowledge of the unique structural motifs and bonding characteristics of boron hydrides	U, An	PSO-1,2,3
CO-3	Understand, analyze and evaluate the structural diversity, bonding characteristics, and reactivity of metal atom clusters	U, An, E	PSO-1,2,3,5
CO-4	Understand the roles of essential and non-essential elements, structural and functional aspects of key biomolecules and their significance in physiological processes and disease treatments.	U, An	PSO-1,2,3,4,5
CO-5	Analyze complex molecular structures, elucidate electronic and geometric properties, and contribute to advancing research in inorganic chemistry.	An, Ap	PSO-1,2,3,5
CO-6	Through active engagement in problem-solving, seminars, discussions, and assessments, develop an understanding of the diverse applications of inorganic chemistry	Ap, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INORGANIC CHEMISTRY III B

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2	R, U	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	U, An	F, C	L	-
3	CO-3	PO-1,6 PSO-1,2,3,5	U, An, E	C, M	L	-
4	CO-4	PO-1,2,6 PSO-1,2,3,4,5	U, An	C, M	L	-
5	CO-5	PO-1,2,6 PSO-1,2,3,5	An, Ap	M	L	-
6	CO-6	PO-1,2,3,4,6 PSO-1,2,3,4,5	Ap, E	P, M	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	-	-	-	1	-	-	-	-	3	-	-
CO 2	3	3	2	-	-	1	1	-	-	-	3	-	-
CO 3	3	3	2	-	1	1	-	-	-	-	3	-	-
CO 4	3	3	1	-	2	1	1	-	-	-	3	-	-
CO 5	2	2	2	-	2	1	1	-	-	-	3	-	-
CO 6	3	3	2	-	2	3	2	2	2	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓	✓	✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE300**				
Course Title	**ENVIRONMENTAL CHEMISTRY III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Fundamental concept of Atmospheric chemistry 2. Basic chemistry of reactions 3. UK3DSECHE200, UK4DSECHE200				
Course Summary	This course gives information regarding composition of earth atmosphere and various factors causing air pollution. This course also highlights mechanism of ozone layer depletion and the strategies adopted for improving the quality of air. This course enlightens the students with the analytical methods adopted for the determination of air quality parameters and policy framework for ensuring the quality of air				

Detailed Syllabus:

Module	Unit	Content ENVIRONMENTAL CHEMISTRY III	Hrs 60
I	**INTRODUCTION AND IMPORTANCE OF ATMOSPHERIC CHEMISTRY**		**9**
	1.1	Introduction to Atmospheric Chemistry	1
	1.2	Composition of atmosphere	2
	1.3	Particles ions and radicals in the atmosphere	2
	1.4	Chemicals and Photochemical reactions in the atmosphere	2
	1.5	Human activities, Meteorology and air pollution	2
II	**AIR POLLUTION – CAUSES, EFFECTS, CONSEQUENCES AND TYPES**		**18**
	2.1	Introduction to air pollution – Major sources of air pollution: Natural and man-made sources Classification of air pollutants, Behaviour and fate of air pollutants	4
	2.2	Major air pollutants – Oxides of Carbon, Nitrogen & Sulphur; Metallic pollutants, Radiation, Particulates – Sources, composition and formation, Industrial pollutants and air pollution	4
	2.3	Effects of gaseous pollutants – Effects of oxides of Carbon, Nitrogen & Sulphur, Hydrocarbons, Particulates and aerosols	3

	2.4	The ozone layer - importance, causes of Ozone layer depletion and its consequences Green House Effect, Global Warming	4
	2.5	Smog, Acid rain, Asbestos dust, Fly ash	3
III	**METHODS FOR MONITORING AIR POLLUTION**		**9**
	3.1	Air quality standards and air quality management	1
	3.2	Monitoring of air pollutants – NO_x, SO_2, H_2S, Ozone, Hydrocarbons, and particulates	2
	3.3	Spectroscopic methods for measuring air pollution – UV, IR, FT-IR and Emission spectroscopy	2
	3.4	Instrumental methods for measuring air pollution – Atomic absorption spectroscopy (AAS), X-ray fluorescence	2
	3.5	Chromatographic techniques for measuring air pollution - Gas chromatography, Ion chromatography, GC-MS, HPLC	2
IV	**CONTROL MEASURES, POLICIES AND CASE STUDIES**		**9**
	4.1	Global and regional problems caused by air pollution; Case studies: Bhopal Gas tragedy, Chernobyl incident	2
	4.2	Methods to control particulates – Gravitational settling chambers and wet collection	2
	4.3	Methods to control gaseous pollutants – adsorption and condensation	2
	4.4	Government policies and legislation in India to control air pollution	1
	4.5	Recent research and advancements in air pollution control, The role of an individual in the protection of atmosphere	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**15**
	1	Introduction to the composition of atmosphere and reactions (both chemical and photochemical) taking place in atmosphere	
	2	Sources, Types, effects and consequence of air pollution	
	3	Analytical methods adopted for the monitoring of air pollutants	
	4	Environmental Disaster caused by air pollution	
	5	Policies and laws enforced for the control of air pollution	

References

1. Balram Pani, *Text Book of Environmental Chemistry*, I.K International Publishing House Pvt Ltd
2. A.K De, *Environmental Chemistry*, Seventh Edition, New Age International Publishers
3. Gray W. vanLoon & Stephen J. Duffy, *Environmental Chemistry: A Global Perspective*, Oxford University Press
4. H. Kaur, *Environmental Chemistry*, Pragati Prakashan
5. V.K Ahluwalia, *Environmental Chemistry*, Second Edition, Ane Books Pvt. Ltd.
6. Ronald A. Bailey, Herbert M. Clark, James P. Ferris, Sonja Krause, Robert L. Strong, *Chemistry of the Environment*, Second Edition, Academic Press
7. Asim K. Das, *Environmental Chemistry with Green Chemistry*, Books and Allied (P) Ltd.

8. G S Sodhi, *Fundamentals Environmental Chemistry*, Second Edition, Narosa Publishing House.

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Help to understand composition of Earth's atmosphere, including the major gases and aerosols present and the chemical reactions that occur in the atmosphere, including gas-phase reactions, photochemical reactions, and heterogeneous reactions on aerosol	U	1,3
CO2	Enable the students to understand the sources, transport, and health effects of air pollutants, including pollutants like nitrogen oxides, sulfur dioxide, and particulate matter, as well as greenhouse gases and ozone-depleting substances.	U	1,3
CO3	Understand the principles regarding air quality management and be familiarized with strategies for reducing emissions of air pollutants and improving air quality.	U, A	1,3
CO4	Explore the analytical techniques for measuring and monitoring air pollutants	A	1,2,3
CO5	Exploring the environmental laws and policy frameworks for protecting the air quality and case studies of disaster relating to air pollution	U	1,3
CO6	Enable the students to understand the methods to control gaseous pollutants and particulates	U	1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY III

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO1	1,3	U	C	L	
2	CO2	1,3	U	F, C	L	
3	CO3	1, 3	U, A	C	L	
4	CO4	1, 2, 3	A	F, C	L	
5	CO5	1, 3	U	F, C	L	

6	CO6	1, 2, 3	U	F, C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 2	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 3	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 4	1	2	1	-	-	1	1	-	-	-	-	-	-
CO 5	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 6	1	2	1	-	-	1	1	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4	✓			✓
CO 5	✓			✓
CO 6	✓			✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK5DSECHE301</td></tr>
<tr><td>Course Title</td><td colspan="5">ENVIRONMENTAL CHEMISTRY IV</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">V</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 - 399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Basic Knowledge in soil chemistry
2. Fundamentals of analytical chemistry
3. UK3DSECHE200, UK4DSECHE200, UK5DSECHE300</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course introduces the soil chemistry and environmental impact of soil chemistry. This course also gives information about the soil remediation Techniques</td></tr>
</table>

Detailed Syllabus:

Module	**Unit**	**Content** **ENVIRONMENTAL CHEMISTRY IV**	**Hrs** **75**
I	**INTRODUCTION AND IMPORTANCE OF SOIL CHEMISTRY**		**9**
	1.1	Introduction to soil Chemistry – Soil formation, texture and soil profile	1
	1.2	Physical, Chemical and biological properties of soil	2
	1.3	Chemical process in soil – ion exchange reactions and soil pH; Redox reactions and nutrient cycling	2
	1.4	Soil colloids: Classification, Properties - charge, stability, zeta potential, flocculation and peptization; sorption properties of soil colloids	2
	1.5	Soil organic matter - fractionation of soil organic matter and different fractions	2
II	**SOIL POLLUTION – CAUSES, TYPES, EFFECTS AND CONSEQUENCES**		**18**
	2.1	Introduction to soil pollution – Major sources of soil pollution: Natural and man-made sources	3
	2.2	Type of soil pollutants – Organic and inorganic contaminants, solid waste, nuclear waste, industrial pollutants, pollutants from agriculture, Mining and Municipal wastes, Heavy metal pollution in soils	5
	2.3	Chemistry of salt-affected soils	2

	2.4	Health hazards, Yield and quality depreciation in agricultural products, Desertification, Pollution of water and air resources due to soil pollution, emission of greenhouse gases and climate change	5
	2.5	Population displacement, Species extinction, Economic Impacts	3
III	**ANALYTICAL METHODS FOR MONITORING SOIL QUALITY**		**9**
	3.1	Soil sampling methods - Grid sampling and Zone sampling	3
	3.2	Determination of soil fertility and productivity	2
	3.3	Determination of pH, N, P, K and soil salinity	2
	3.4	Determination of moisture content, conductivity and organic carbon of soil	1
	3.5	Mechanical analysis of soil – methods of soil particle size analysis	1
IV	**CONTROL MEASURES, POLICIES AND CASE STUDIES**		**9**
	4.1	Need to control soil pollution; Methods to prevent soil pollution – Biofertilizers, natural pesticides, Ecological farming	2
	4.2	Bioremediation of contaminated soil – mycoremediation and phytoremediation, use of biodegradable polymers	2
	4.3	Soil erosion - Forms, effects and factors affecting soil erosion; Conservation of soil	2
	4.4	Government policies and legislation in India to control soil pollution	1
	4.5	Case studies; Role of an individual in the conservation of soil	2
V	**SOIL ANALYSIS PRACTICALS II**		**30**
	1	Determination of Soil pH by pH meter -Minimum 5 Samples	
	2	Determination of Bulk density and moisture content by physical method - Minimum 5 Samples	
	3	Determination of organic matter and organic carbon content in soil by Titrimetric Method-Minimum 5 samples	
	4	Determination of electrical conductivity of soil by conductivity method-Minimum 5 samples	
	5	Determination of specific gravity of soil samples-minimum 5 samples	

Reference

1. Balram Pani, *Text Book of Environmental Chemistry*, I.K International Publishing House Pvt Ltd
2. A.K De, *Environmental Chemistry* Seventh Edition, New Age International Publishers
3. Gray W. van Loon & Stephen J. Duffy, *Environmental Chemistry: A Global Perspective*, Oxford University Press
4. H. Kaur, *Environmental Chemistry*, Pragati Prakashan.
5. V.K Ahluwalia, *Environmental Chemistry*, Second Edition, Ane Books Pvt. Ltd.
6. Ronald A. Bailey, Herbert M. Clark, James P. Ferris, Sonja Krause, Robert L. Strong, *Chemistry of the Environment*, Second Edition, Academic Press
7. Asim K. Das, *Environmental Chemistry with Green Chemistry*, Books and Allied (P) Ltd.
8. G S Sodhi, *Fundamentals Environmental Chemistry*, Second Edition, Narosa Publishing House.

9. A.K De, *Environmental Chemistry* Seventh Edition, New Age International Publishers
10. S.M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
11. Balram Pani, *Text Book of Environmental Chemistry*, I.K International Publishing House Pvt Ltd
12. Gray W. van Loon & Stephen J. Duffy, *Environmental Chemistry: A Global Perspective*, Oxford University Press
13. H. Kaur, *Environmental Chemistry*, Pragati Prakashan.
14. V.K Ahluwalia, *Environmental Chemistry*, Second Edition, Ane Books Pvt. Ltd.

Course outcome

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Understand the fundamental principles of soil chemistry, including soil composition, soil properties, mineralogy, and the role of organic matter,	U	1,3
CO2	Enable the students to understand laboratory techniques used for soil chemical analysis, such as pH measurement, nutrient extraction, and the influence of soil chemistry on crop productivity.	U, A	1,2,3
CO3	Explore the environmental impact of soil chemistry, including nutrient runoff, soil pollution, and the effects of soil management practices on water quality and ecosystem health.	A	1,2,3
CO4	Provide an insight into soil remediation techniques for contaminated soils, including mycoremediation, phytoremediation, and soil erosion	U	1,3
CO5	Provide information regarding the policy framework for soil conservation and case studies regarding disaster caused by soil pollution	U	1,3
CO-6	Acquire practical knowledge and hands-on experience in analytical techniques commonly used in soil analysis, such as pH measurement, soil texture analysis, nutrient analysis (e.g., nitrogen, phosphorus, potassium), soil organic matter determination by pH meters, spectrophotometers, atomic absorption spectrophotometers, flame photometers, and other specialized equipment.	A	1,2,3,4

R-Remember, U-Understand Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY IV

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)

1	CO1	1,3	U	C	L	
2	CO2	1,2,3	U, A	F, C	L	
3	CO3	1,2,3	A	C	L	
4	CO4	1,3	U	F, C	L	
5	CO5	1,3	U	F, C	L	
6	CO6	1, 2, 3, 4	A	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 2	1	2	1	-	-	1	1	-	-	-	-	-	-
CO 3	1	1	1	-	-	1	1	-	-	-	-	-	-
CO 4	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 5	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 6	1	2	1	1	-	1	1	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

ssessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓			✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE302**				
Course Title	**CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Familiarity with conventional and renewable energy technologies, energy conversion processes, and energy storage systems. 2. Competence in spreadsheet software and simulation software for energy analysis 3. UK3DSECHE201, UK4DSECHE201				
Course Summary	• This course offers a comprehensive exploration of carbon-based materials, solar thermal power technology, advanced nanomaterials, and bioenergy systems, focusing on their structures, properties, applications, and sustainable energy production. • Through discussions, students engage in hands-on learning and critical analysis to understand the significance of policy, technology, and innovation in addressing environmental challenges associated with renewable energy materials.				

Detailed Syllabus:

Module	Unit	Content **CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- III**	Hrs 60
I	**CARBON-BASED MATERIALS FOR ENERGY APPLICATIONS**		**9**
	1.1	Carbon-Based Materials for Energy Applications: Introduction C60 and its crystal-From a Graphene Sheet to a Nanotube – Single wall and Multi walled Nanotubes - Zigzag and Armchair Nanotubes - Euler's Theorem in Cylindrical and Defective Nanotubes, Structure and Bonding.	2
	1.2	Fullerenes: Structure and Bonding- Nomenclature, The Structure of C60, Structure of Higher Fullerenes Growth Mechanisms;	1
	1.3	Production and Purification, Physical and Chemical Properties. Carbon nanotubes: Structure and Nomenclature of Carbon Nanotubes (SWCNT and MWCNT). Structure and production of other tubular carbon materials	2

	1.4	Graphene: Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Applications of carbon nanomaterials	2
	1.5	Electronic Properties - Band Structure of Graphene - Mobility and Density of Carriers Quantum Hall Effect.	1
	1.6	Application fullerene, CNT, Graphene and other carbon nanomaterials - Mechanical, Thermal, Applications	1
II	**SOLAR THERMAL POWER TECHNOLOGY**		**9**
	2.1	Solar Thermal Power Technology: Solar radiation, Solar angles, classifications of Solar thermal collectors, Water distillation, Refrigeration, Building heating and cooling, Cooking, Drying.	3
	2.2	Emerging solar thermal technologies, Application of solar thermal technologies: Power generation, Industrial process heating	2
	2.3	Thermal energy storage systems. Thermochemical energy storage, Integration of thermal energy systems with various end use applications	1
	2.4	Sensible, Latent, and, Economic analyses of solar thermal energy systems, Life cycle assessment of solar thermal energy systems.	1
	2.5	Helio-electric conversion, Photo-voltaic conversion, indirect utilization through water power- Ocean Thermal Energy Conversion (OTEC), Solar ponds	2
III	**ADVANCED MATERIALS FOR ENERGY APPLICATIONS**		**9**
	3.1	Introduction of nanoscale porosity in organic and inorganic Microporous and mesoporous materials: Impact of nanoscale porosity and surface acidity/basicity in the energy and environmental research.	**3**
	3.2	nanoparticles and quantum dots. Applications of nanoparticles, quantum dots, nanotubes, and nanowires for nanodevice fabrication.	**3**
	3.3	Composites: Metal matrix composites, Polymer matrix composites, Ceramic matrix composites, Hybrid composites, Applications of composites.	**3**
IV	**ADVANCEMENTS IN BIOENERGY: FROM BIOMASS TO BIOFUELS-ENERGY SYSTEMS MODELLING AND ANALYSIS**		**18**
	4.1	Introduction to Bioenergy, Biomass Harvesting Characterization of Biomass Feedstock Classification of Biomass Feedstock, Pre-treatment Processes of Biomass, Production Routes for Biomass Conversion to Biofuels: Biochemical Methods, Chemical Processes, Thermochemical Methods	4
	4.2	Biodiesel – the mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel engine utilization Alcohol production from biomass- types of materials of alcohol production description, utilization Modern biofuel synthesis Bio- refinery Energy plantation, Overview on energy plantation, Basis of selecting the plants for energy plantation. Waste land utilization through energy plantation	5
	4.3	Energy Chain and Primary Energy Analysis Quantitative Techniques: Interpolation techniques such as polynomial, Lagrangian, and curve fitting Regression analysis Quantitative Techniques:	3
	4.4	Systems simulation involves constructing information flow diagrams to represent the interactions between different components of an energy system.	3

	4.5	Problem formulation involves defining the decision variables, objectives, and constraints. Unconstrained optimization problems require finding the minimum or maximum of a function, Constrained optimization involves optimizing a function subject to equality and inequality constraints, with Lagrange multipliers and Kuhn-Tucker conditions	3
V	**OPEN ENDED MODULE: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
	1	Understand the different types of renewable Energy materials	
	2	Explore innovative solutions and emerging technologies for sustainable energy production and consumption using renewable energy materials	
	3	Evaluate participation in class discussions, case study analyses, and group projects.	
	4	Encourage critical thinking and creativity in the development of solutions-oriented projects that address real-world environmental challenges associated with conventional energy materials	
	5	Evaluate the role of policy, technology, and behavior change in transitioning to sustainable energy systems and renewable enrgy materials	

References

1. Mukunda H.S, *Understanding Clean Energy and Fuels from Biomass.* Wiley-India Pvt. Ltd, 2011
2. Optimization of Energy Systems, *I. Dincer, M.A. Rosen, P. Ahmadi*, Wiley Online Library, 2017
3. Pandey A. *Handbook of Plant-Based Biofuel.* CRC Press, Taylor & Francis, 2008
4. *Intelligent Renewable Energy Systems: Modeling and Control*, G. Rigatos, Springer, 2016
5. Mital KM. *Biogas Systems, Principles and Applications.* New Age International Ltd., 1996
6. Innovative Advanced Materials for Energy Storage and Beyond: Synthesis, Characterization and
7. Rai GD. *Non-Conventional Energy Sources.* Khanna Publication, 2001
8. Ravindranath NH. Hall DO. *Biomass, Energy, and Environment: A Developing Country Perspective from India.* Oxford University Press, 1995
9. Optimization of Energy Systems, *I. Dincer, M.A. Rosen, P. Ahmadi*, Wiley Online Library, 2017
10. *Modeling Power Electronics and Interfacing Energy Conversion Systems*, M.G. Simões, F.A. Farret, John Wiley & Sons, 2016
11. Sharma, S., & Singh, P. (2023). *Carbon-Based Materials for Energy Applications.* New Delhi: Springer India. ISBN: 978-981-175-433-4
12. Gupta, R., & Kumar, A. (2023). *Advancements in Solar Thermal Power Technology.* New Delhi: PHI Learning Pvt. Ltd. ISBN: 978-938-134-579-1
13. Patel, M., & Mishra, A. (2023). *Advanced Nanomaterials for Energy Storage and Conversion.* New Delhi: Elsevier India. ISBN: 978-012-823-556-6
14. Verma, R., & Sharma, S. (2023). *Bioenergy: From Concepts to Applications.* New Delhi: CRC Press. ISBN: 978-103-207-648-3
15. Agarwal, S., & Gupta, M. (2023). *Renewable Energy Systems: Modeling and Analysis.* New Delhi: Taylor & Francis. ISBN: 978-036-763-830-0

16. Sharma, P., & Yadav, A. (2023). *Solar Thermal Power Technology: Innovations and Challenges.* New Delhi: Springer India. ISBN: 978-981-17

Course Outcomes

No.	Upon completion of the course, the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Upon completion, students should be familiar with various carbon nanomaterials, such as carbon nanotubes (CNTs), graphene, carbon nanofibers (CNFs), and fullerenes, and their unique properties and applications.	R, U	1,3
CO-2	Students updated with emerging trends, innovations, and research advancements in the field of solar thermal power technology. Students will be capable of conducting OTEC resource assessments and site analyses to identify suitable locations for OTEC deployment.	R, U, An	1,3
CO-3	Students should be aware about the advanced materials for energy applications and advancements in bioenergy technologies	U	1,3
CO-4	To understand the fundamental principles underlying energy systems modeling and analysis, including system boundaries, modeling approaches, optimization techniques, and data analysis methods	A	1,3
CO-5	To develop a comprehensive understanding of renewable energy materials, foster exploration of innovative solutions for sustainable energy production, and evaluate critical thinking and participation in discussions and projects addressing real-world environmental challenges.	An, Ap,E	1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY- III

Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	R, U	F, P	L	
2	CO-2	1,3	R, U, An	F, C	L	
3	CO-3	1,3	U	F, P	L	
4	CO-4	1,3	A	M, P	L	
5	CO-5	1,2,3,4	An, Ap, E	F, C, M, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PO1	PO2	PO3	PO4	PO 5	PO6	PO 7	PO8
CO 1	2	-	3	-	-	3	2						
CO 2	3	-	3	-	-	3	2	2					
CO 3	2	-	3	-	-	3	3						
CO 4	3	-	3	-	-	2	3	1					
CO 5	3	3	1	3	-	3	2	2				3	

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4		✓	✓	✓
CO 5		✓		✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK5DSECHE303</td></tr>
<tr><td>Course Title</td><td colspan="5">CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY IV</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">5</td></tr>
<tr><td>Academic Level</td><td colspan="5">300-399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. A strong grasp of basic principles in physics and chemistry is essential for comprehending the mechanisms behind renewable energy technologies.
2. Understanding statistical methods is beneficial for analyzing energy data and making informed decisions in renewable energy projects.
3. UK3DSECHE201, UK4DSECHE201</td></tr>
<tr><td>Course Summary</td><td colspan="5">• The course offers a thorough examination of renewable energy sources such as solar, wind, biomass, and hydrogen, detailing their evolution, operational principles, applications, and environmental implications.
• Through practical lab sessions focusing on semiconductor evaluation, solar radiation measurement, solar cell modelling simulation, and fuel characterization, students develop both hands-on expertise and theoretical comprehension in the realm of renewable energy.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content **CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY IV**	Hrs 75
I	**SOLAR ENERGY**		**9**
	1.1	Introduction to solar energy: - Historical development of solar energy technologies. Different types of energy sources, various methods of energy conversion, solar radiations, Radio metric properties, and Black body radiations. Solar spectra	3
	1.2	History of solar cells, Types of solar cells: Crystalline silicon solar cells, Thin film solar cells and multi-junction solar cells	2
	1.3	Alternative methods of solar energy utilization: solar thermal energy, solar fuels and limitations of solar energy	1

	1.4	Solar photovoltaic technologies, Generation and recombination of electron-hole pair, working principles of solar cell and applications	3
II	**WIND ENERGY**		**9**
	2.1	Overview of wind energy, Historical development, Basics of wind physics and meteorology, Composition of wind, Atmospheric chemistry and dynamics Wind Energy Conversion Systems-Introduction-Components of WECS - Fixed speed drive scheme- Variable speed drive scheme - Wind–Diesel Hybrid System –Induction generators. Doubly Fed Induction Generator (DFIG)-Squirrel Cage Induction Generator (SCIG)-Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters (Block Diagram Only)-Effects of Wind Speed and Grid Condition (System Integration) -Environmental Aspects -Wind Energy Program in India	3
	2.2	Materials science in wind turbine design, Chemistry of rotor blades, tower materials, and gear systems, Corrosion and degradation in wind turbines, Generators and power electronics	2
	2.3	Chemistry of electrical energy conversion, Battery technologies for wind energy storage, Chemical storage systems (hydrogen, ammonia, etc.)	2
	2.4	Environmental chemistry of wind energy, Impacts on wildlife and ecosystems, Mitigation strategies and sustainable practices, Cost analysis of wind energy production, Government policies and incentives	2
III	**BIOMASS CONVERSION AND HYDROGEN ENERGY**		**9**
	3.1	Overview of biomass: types, sources, and composition, Chemical structure of biomass components	1
	3.2	Gasification: thermochemical conversion to syngas, Combustion: biomass burning for energy generation and practical applications, Anaerobic digestion: microbial breakdown of biomass.	2
	3.3	Fermentation: production of biofuels and chemicals, Enzymatic conversion: enzymatic hydrolysis of biomass, Catalytic conversion: upgrading biomass-derived intermediates.	2
	3.4	Hydrothermal processing: aqueous phase conversion, Fischer-Tropsch synthesis: conversion to liquid fuels, Hydrogen Production and Utilization, Hydrogen production methods: steam reforming, electrolysis, biomass reforming	2
	3.5	Hydrogen storage: challenges and solutions, Fuel cells: principles and applications, Hydrogen as a clean energy carrier: benefits and limitations	2
IV	**BATTERY TECHNOLOGY, FUEL CELLS, AND CARBON CAPTURE AND UTILIZATION**		**18**
	4.1	Overview of batteries: Definition, Types: lead-acid, lithium-ion, nickel-metal hydride. Basic components of a battery: electrodes, electrolyte, separator	2
	4.2	Electrochemical reactions in batteries: charge and discharge processes, Comparison of battery chemistries: energy density, cycle life and charging characteristics Components and Design, Electrodes: materials, structures, and functions Electrolytes: types, properties, role in battery operation, Battery pack design: cell arrangement, thermal management, safety considerations, Battery Performance and Testing Advancements in battery research: nanomaterials,	4

		artificial intelligence in battery management. Environmental impact and sustainability in production and disposal of battery.	
	4.3	Introduction to Overview of fuel cell technologies. Types of fuel cells: Proton Exchange Membrane Fuel Cells (PEMFCs), Solid Oxide Fuel Cells (SOFCs), Alkaline Fuel Cells (AFCs), etc.	3
	4.4	Electrode kinetics and thermodynamics in fuel cells, Performance matrix Efficiency considerations, Challenges and Opportunities in different cells Applications of fuel cells in transportation, stationary power generation, and portable electronics	4
	4.5	Carbon capture from industrial processes and power plants CO2 utilization pathways: carbonation, mineralization, biological conversion..	3
	4.6	Life cycle analysis of fuel cells and CCU technologies, Advanced materials for fuel cells and CO2 utilization.	2
V	**OPEN ENDED MODULE: PRACTICALS-II**		**30**
	1	Evaluate the properties of semiconductors for the application in the energy field	
	2	Solar radiation measurement	
	3	Wavelength-dependent energy conversion efficiency from solar cell	
	4	Numerical simulation training for modeling a Solar cell Determination of first and second figures of merit (F1 and F2) of a box-type solar cooker.	
	5	Elemental characterization of a fuel using a CHNS(O) analyzer	

References

1. *Advanced Lithium-Ion Batteries: Recent Trends and Perspectives* by C. Retna Raj, V. Ramamurthy and S. Hariharan (2018)
2. *Battery Operated Devices and Systems*: From Portable Electronics to Industrial Products by Vinod Kumar Khanna (2015)
3. *Biomass and Bioenergy* by Hakeem, K. R., Jawaid, M., & Rashid, U. (2016).
4. *Biomass Conversion*: Emerging Technologies and Applications by A. Thimmaiah Gowda and R. K. Mallik (2017)
5. *Biomass Conversion*: The Interface of Biotechnology, Chemistry, and Materials Science by Senthil, Chinnasamy, Johnson, David K., & Serrano-Ruiz, Juan Carlos (1st Edition, 2012).
6. *Carbon Capture and Storage: Technologies, Policies, Economics, and Implementation Strategies* by B. Sengupta and B.K. Parida (2017)
7. *Carbon Capture and Utilization*: A Strategic Tool for Indian Industries by D. N. Singh and C. K. Pradhan (2019)
8. *Chemistry of Sustainable Energy* by Dyson, Peter G. L. (2nd Edition, 2018).
9. *Fuel Cell Technology and Appl*ications by Sanjib Kumar Panda and Pijush Kanti Bhattacharjee (2015)
10. *Fuel Cells: Principles, Design, and Analysis* by Murat O. Balaban and S.P. Sukhatme (2019)
11. *Hydrogen Production and Remediation of Carbon and Pollutants* by Linardi, Marcelo, & Sant'Ana, Antonio Carlos (1st Edition, 2015).
12. *Introduction to Biomass Energy Conversions* by Jayant Baliga and Raka Datta (2016)

13. *Modeling Power Electronics and Interfacing Energy Conversion Systems* by Simões, M. G., & Farret, F. A. (2016).
14. *Non-Convention Energy Resources* by Singh, Shobh Nath (2018).
15. *Photovoltaic Systems and Their Integration* by Saurabh Kumar Rajvanshi (2017)
16. *Principles of Solar Engineering* by Goswami, D. Yogi (3rd Edition).
17. *Solar Energy Technology Handbook* by Dickinson, E. W. (2018).
18. *Solar Photovoltaics: Fundamentals, Technologies, and Applications* by Chetan Singh Solanki (2019)
19. *Wind Energy Explained: Theory, Design and Application* by Manwell, James F., McGowan, Jon G., & Rogers, Anthony L. (2nd Edition, 2009).

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students should gain a comprehensive understanding of various renewable energy technologies, including solar, wind, hydroelectric, geothermal, and biomass energy systems	R, U, Ap	1,3
CO-2	Students should be aware about the fundamental principles of solar and wind energy, including solar radiation, wind dynamics, and the conversion of solar and wind energy into electricity.	R, U	1,3
CO-3	Students can develop a holistic understanding of renewable energy systems and their role in the transition to a more sustainable energy future	U, An	1,3
CO-4	Students will develop a thorough understanding of the fundamental principles underlying battery technology, including electrochemistry, battery components, charge-discharge mechanisms, and battery performance metrics.	R, U	1,3
CO-5	Students will possess the ability to analyze semiconductor properties relevant to energy applications, measure solar radiation, simulate solar cell behavior, evaluate the efficiency of solar cells based on wavelength dependence, determine figures of merit for solar cookers, and conduct elemental characterization of fuels using CHNS(O) analysis.	R, U, Ap	1,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY IV

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	R, U, Ap	F, C	L	
2	CO-2	1,3	R, U	F, C, P, M	L	
3	CO-3	1,3	U, An	F, C, P	L	
4	CO-4	1,3	R, U	F, C	L	
5	CO-5	1,3,5	R, U, Ap	F, C, P, M		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	-	3	-	-	3	2	-	-	-	-	-	-
CO 2	2	-	3	-	-	3	3	-	-	-	-	-	-
CO 3	2	-	3	-	-	3	2	2	-	-	-	-	-
CO 4	1	-	3	-	-	2	3	1	-	-	-	-	-
CO 5	3	-	2	-	3	3	3	3	-	-	-	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓	✓	✓
CO 5		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE304**				
Course Title	**ANALYTICAL CHEMISTRY -III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Foundational understanding of chemistry principles, including chemical bonding, molecular structure, and chemical reactions. 2. Prior knowledge of basic analytical chemistry principles, such as the interaction of analytes with different separation techniques.				
Course Summary	This course provides students with an in-depth understanding of various analytical chemistry techniques, including spectroscopic methods, thermal analysis, and Chromatographic techniques.				

Detailed Syllabus:

Module	Unit	Content ANALYTICAL CHEMISTRY -III	Hrs 60
I	**THERMAL METHODS OF ANALYSIS**		**9**
	1.1	Thermal Methods of Analysis: Introduction, Thermogravimetric Analysis & Differential Thermal Analysis: Principle, Instrumentation, Sources of Error in TGA, Interpretation of TG Curve, Factors Affecting TG Curve, Applications of TGA & DTA	4
	1.2	Differential Scanning Calorimetry (DSC)-Principle, Instrumentation, Applications of DSC.	2
	1.3	Thermomechanical Analysis (TMA) and Dynamic Mechanical Analysis (DMA), Principle and Applications of TMA, DMA.	3
II	**SPECTROSCOPIC METHODS OF ANALYSIS I**		**9**
	2.1	Overview of Spectroscopy: EMR and its Interaction with Matter	1
	2.2	Basic Components of Spectroscopic Instrumentation: Sources of Energy, Wavelength Selection, Sample cells, Detectors, Slit width, Instrumental wavelength (for visible, UV, IR, fluorescence)	2
	2.3	Spectroscopy Based on Absorption: Absorbance and Transmittance, Beer-Lambert's Law, Its limitations	1

	2.4	Ultraviolet-visible Spectrophotometry: Principle, Instrumentation, molecular structure (transitions, absorption by isolated, conjugated & aromatic chromophores) Applications	3
	2.5	Infrared Spectrophotometry: Principle, Instrumentation, Absorption by functional groups, applications, introduction to NIR spectroscopy	2
III	**CHROMATOGRAPHIC TECHNIQUES I**		**9**
	3.1	General description of chromatography, Principles of Chromatographic separations, Classification of chromatography: Adsorption, Partition, Ion exchange and Size exclusion chromatography	2
	3.2	General Theory of Column Chromatography, Theory of Column Efficiency, Chromatographic Resolution, Capacity Factor, Column Selectivity, Column Efficiency, Optimizing Chromatographic Separations,	4
	3.3	Gas Chromatography: GC columns—packed, capillary, Stationary phases—polar to nonpolar, GC detectors, introduction to GC-MS, Applications	3
IV	**CHROMATOGRAPHIC TECHNIQUES II**		**18**
	4.1	Liquid Chromatography: High-Performance Liquid Chromatography, Stationary Phases in HPLC, Chiral Stationary Phases	3
	4.2	Equipment for HPLC, Detectors (Universal detectors, refractive index detectors, Viscosity and light scattering detectors, UV-Visible detectors), introduction to Open Tubular Liquid Chromatography (OTLC)	3
	4.3	Ion chromatography: Ion exchange separation of amino acids and PCR	3
	4.4	Thin-layer chromatography (TLC), Rf values, TLC stationary and mobile phases, TLC sample application, HPTLC: development, gradient elution, spot visualization, quantitative measurements	3
	4.5	Paper chromatography: principle, solvent systems, mechanism of paper chromatography, different development methods: ascending, descending, horizontal, circular spreading	3
	4.6	Electrophoresis: Electrophoresis, CZE, Slab gel and Capillary gel electrophoresis	2
	4.7	Introduction to Micellar electrokinetic chromatography (MEKC), Capillary electrochromatography	1
V	**Open Ended Module: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc.**		**15**
	1.	Provide a detailed interpretation of the TG curve of Calcium oxalate monohydrate, and discuss the factors influencing the curve.	
	2.	Write a report on the applications of near-infrared (NIR) spectroscopy in non-destructive testing in a specific industry of your choice.	
	3.	Measure the absorption spectra of known compounds and calculate the concentration using Beer-Lambert's Law.	
	4.	Discuss the principles of NIR absorption and its advantages in quality control and product analysis.	
	5.	Compare and contrast gas chromatography (GC) and liquid chromatography (LC) in terms of their applications and	

		advantages/disadvantages. Provide examples of real-world scenarios where each technique would be most suitable.	
	6.	Design an experiment to separate and analyze specific biomolecules using capillary gel electrophoresis.	
	7.	Explore recent advancements in thermal analysis methods and their applications in materials science, pharmaceuticals, and environmental analysis.	
	8.	Present case studies on the use of chromatographic techniques in forensic science, food safety, and drug discovery, highlighting novel approaches and challenges faced in real-world scenarios.	

References

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Text Book of Practical Organic Analysis*, Longman, 5th edition, 1989.
2. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry,* Saunders College Publishing, 7th edition, 1996.
3. J. R. Dyer, *Applications of Absorption Spectroscopy of Organic Compounds*, Prentice 2, Hall, 1974.
4. D. H. Williams and I. Fleming, *Spectroscopic methods in organic chemistry*, 6th Edition, Tata McGraw Hill, 2011.
5. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. A. Vyvyan, *Introduction to Spectroscopy*, 4th Edition, Brooks Cole, 2008.
6. Y. R. Sharma, *Elementary Organic Spectroscopy*, S. Chand Publishing, 2010.
7. D. J. Holme and H. Perk, *Analytical Biochemistry*, 3rd edition, Prentice Hall, 1998.
8. B. K. Sharma, Analytical Chemistry, Krishna Prakashan Media (P) Ltd., 2nd Edition, 2006
9. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
10. D. A. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.
11. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House.

Course Outcomes

No.	**Upon completion of the course, the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding of various thermal analysis techniques and their instrumentation.	U, Ap	1
CO-2	Proficiency in UV-visible and Infrared Spectrophotometry, including quantitative and qualitative applications.	Ap, E	1& 2

CO-3	Proficiency in the theory of column chromatography and gas chromatography techniques including instrumentation and quantitative measurements.	U, Ap	1 &2
CO-4	Familiarity with thin-layer chromatography, Paper Chromatography and electrophoresis techniques & competency in liquid chromatography	U	1 &2
CO-5	Applies the knowledge obtained from the course to relevant situations	Ap	3 & 5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL CHEMISTRY III

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1	U, Ap	F	L	
2	CO-2	PO-1 & 2 PSO-1& 2	Ap, E	C	L	
3	CO-3	PO-1 & 2 PSO-1 &2	U, Ap	C	L	
4	CO-4	PO-1 & 2 PSO-1 &2	U	C	L	
5	CO-5	PO-2,3, & 4 PSO- 3 & 5	Ap	M	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	2	-	-	-	-	2	2	-	-	-	-
CO 3	2	2	-	-	-	-	2	2	-	-	-	-

CO 4	2	2	-	-	-	-	2	2	-	-	-	-
CO 5	-	-	3	3	-	-	-	3	3	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√			√
CO 2	√			√
CO 3	√	√		√
CO 4	√			√
CO 5		√	√	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE305**				
Course Title	**ANALYTICAL CHEMISTRY- IV**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3hours	-	2	5
Pre-requisites	1. Prior knowledge of basic analytical chemistry principles, such as the interaction of analytes with different separation methods 2. Prior knowledge of electrochemical cells, electrode potentials, and the Nernst equation is necessary. 3. Understanding voltaic cells, anodes, cathodes, and cell voltages. 4. UK3DSECHE202, UK4DSECHE202, UK5DSECHE304				
Course Summary	In-depth understanding of various analytical Separation techniques and electrochemical methods used in analytical chemistry				

Detailed Syllabus:

Module	**Unit**	**Content** **ANALYTICAL CHEMISTRY - IV**	**Hrs** **75**
I	**ELECTROCHEMICAL METHODS OF ANALYSIS**		**9**
	1.1	Classification of Electrochemical Methods, Potentiometers & Potentiometric methods of analysis, Potentiometric Measurements: Potentiometric Electrochemical Cells, Potential and Concentration-The Nernst Equation, Liquid junction potential	3
	1.2	Reference Eletrode: SHE, Saturated Calomel Electrode, Potentiometric Titrations: Principle, Detection of Endpoints, Derivative methods of locating end points.	2
	1.3	pH Meter, Standard Buffers Reference for pH Measurements, Accuracy of pH Measurements, Working of pH meter.	2
	1.4	pH Measurements in Nonaqueous Solvents, Ion Selective electrodes: Glass membrane electrodes	2
II	**INTRODUCTION TO ANALYTICAL SEPARATION**		**9**
	2.1	Classification of separation techniques (based on size, mass/density, change of state, partitioning between phases)	3

	2.2	Separation of Species by Distillation: Different distillation Techniques: Simple, fractional, Vacuum, Steam distillation	3
	2.3	Separation of Species by Distillation: Different distillation Techniques: Simple, fractional, Vacuum, Steam distillation	3
III	**ANALYTICAL SEPARATION II**		**9**
	3.1	Supercritical Fluid Extraction: Properties of Supercritical Fluids, Instrumentation and operating variable	2
	3.2	Solvent Extraction: Factors favouring solvent extraction, Quantitative treatment of solvent extraction equilibria, Synergistic extraction, Batch Extraction, Craig's Technique of Liquid-liquid extraction.	3
	3.3	Solid Phase Extraction, SPE Cartridges, SPE Pipet Tips, SPE Disks, and other sorbents for SPE	2
	3.4	Centrifugation: Principle, Categories (isopycnic, density gradient, ultrafiltration, phase separation, and pelleting), Types of centrifuges, Application	2
IV	**ELECTRO Analytical Methods & Kinetic Methods of Analysis**		**18**
	4.1	Electro gravimetry: Theory, Terms used in electro-gravimetric analysis, Completeness of deposition, Electrolytic separation of metals	4
	4.2	Conductometry: Introduction, Applications of conductometric measurements, The basics of conductometric titrations, Apparatus and Applications of conductometric titrations,	4
	4.3	Coulometry: Introduction, Coulometry at controlled potential, Apparatus, Separation of nickel and cobalt by coulometric analysis at controlled potential, Introduction to Flowing stream coulometry	4
	4.4	Methods Based on Chemical Kinetics: Classifying chemical Kinetic Methods, Representative Methods: Determination of Creatinine in Urine, Instrumentation,	3
	4.5	Radiochemical Methods of Analysis: Theory & Practise, Quantitative Applications: Direct Analysis of Radioactive Analytes, Neutron Activation Analysis, Characterization Applications	3
V	**ANALYTICAL CHEMISTRY PRACTICALS II**		**30**
		Section A **(All experiments in section A are compulsory)**	
	A	Separation of components from various Mixtures and check the purity of the components using TLC (a) Separation of components from a mixture of (i) aniline and toluene. (ii) O-cresol /β-naphthol and cinnamic acid/benzoic acid (iii) Cinnamic acid and aniline (iv) Benzoic acid and toluene (b) Paper chromatographic Separation of a mixture of inks or sugars	
		Section B & Section C **(Any 5 experiments from B and C need to be done)**	
	B	(i) Separation of metal ions by Solvent extraction using TOPO/TPPO/ crown ethers as the chelating agent and analyze the extraction efficiency using UV-Vis spectroscopy	

		(ii) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography (iii) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin-layer chromatography (TLC) (iv) Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Fe (III) and Al (III)	
	C	Perform the following conductometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base Perform the following potentiometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base iv. Potassium dichromate vs. Mohr's salt	

References

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Text Book of Practical Organic Analysis*, Longman, 5th edition, 1989.
2. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.
3. D. J. Holme and H. Perk, *Analytical Biochemistry,* 3rd edition, Prentice Hall, 1998.
4. B. K. Sharma, *Analytical Chemistry*, Krishna Prakashan Media (P) Ltd., 2nd Edition, 2006
5. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
6. D. A. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.
7. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House.
8. H. W. Nürnberg, *Electroanalytical Chemistry*, Wiley-Interscience, 1974.
9. H. H. Willard, L.L. Jr., J.A.Dean, F.A. Jr. Settle, *Instrumental Methods of Analysis*, CBS Publishers & Distributors, 7th Edition, 1986.
10. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Text book of Quantitative Inorganic Analysis*, Longman, Fifth Edition, 1989.
11. Gurdeep Raj, *Advanced Practical Inorganic chemistry*; GOEL publishing House
12. D. V. Jahagirdar, *Experiments in Chemistry*, Himalaya Publishing House.
13. B. D Khosla, V. C.Garg, Gulati, *A. Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Mastery of potentiometric electrodes and redox titrations.	Ap, An	1
CO-2	Understanding the principles of separation efficiency and various separation techniques.	U, Ap	2
CO-3	Mastery of solvent extraction and solid-phase extraction techniques.	Ap, An	2
CO-4	Understand the theory of electro-gravimetric analysis, the application of conductimetry and coulometry as an analytical tool & attain knowledge about Kinetic Methods of Analysis	U	2
CO-5	Proficiency in performing Separation of components from mixtures, Conductometric and Potentiometric Experiments.	Ap	1,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL CHEMISTRY IV

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1 PSO-1	Ap, An	F, C	L	
2	CO-2	PO-1 PSO-2	U, Ap	C	L	
3	CO-3	PO-1 PSO-2	Ap, An	C	L	
4	CO-4	PO-1 PSO-2	U	F, C	L	
5	CO-5	PO-2 & 6 PSO-1	Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-	2	-	-	-	-	-
CO 2	-	2	-	-	-	-	2	-	-	-	-	-
CO 3	-	2	-	-	-	-	2	-	-	-	-	-
CO 4	-	2	-	-	-	-	2	-	-	-	-	-
CO 5	2	-	3	-	-	-	-	2	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√	✓	√
CO 4	√	√		√
CO 5	√	√		

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK5DSECHE306</td></tr>
<tr><td>Course Title</td><td colspan="5">INDUSTRIAL CHEMISTRY-III</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">5</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 - 399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>4 hours</td><td>-</td><td></td><td>4</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">UK3DSECHE 203
UK4DSECHE 203</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course equips students with the theoretical knowledge and practical skills required for various processes and industries related to metallurgy, silicate industries, fertilizers, surface coatings, and alloys, fostering critical thinking and problem-solving abilities.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content INDUSTRIAL CHEMISTRY-III	60
I	**METALLURGICAL PROCESSES**		**9**
	1.1	Concentration of ores – gravity separation, magnetic separation and froth floatation processes with suitable examples.	2
	1.2	Metallurgical process - pyrometallurgy –calcination, roasting, sintering, and smelting.	2
	1.3	Hydrometallurgy – leaching and reduction from solution with one example-copper (principle and chemical equations only). Electrometallurgy – molten salt electrolysis and aqueous solution electrolysis with one example -Aluminum (principle and chemical equations only).	3
	1.4	Reducing agents in metallurgy – C, CO, hydrogen, metals with at least one Example, Van Arkel method, zone refining.	2
II	**SILICATE INDUSTRIES**		**9**
	2.1	Glass: glassy state and its properties, classification (silicate and non-silicate glasses), Manufacture and processing of glass. Composition and properties of the following types of glasses: soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.	3

	2.2	Ceramics: Important clays and feldspar, ceramic, their types and manufacture, High technology ceramics and their applications, super conducting and semi conducting oxides, fullerenes,carbon nanotubes and carbon fiber.	3
	2.3	Cements: Classification of cement, ingredients and their role, manufacture of cement and the setting process, quick setting cements.	3
III	**FERTILIZERS**		**9**
	3.1	Inorganic fertilizers – essential nutrients for plants – nitrogenous, phosphatic and potash fertilizers.	**3**
	3.2	Manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates.	**3**
	3.3	Manufacture of polyphosphate, super phosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.	**3**
IV	**SURFACE COATINGS AND ALLOYS**		**18**
	4.1	Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings, Paints and pigments-formulation, composition and related properties.	3
	4.2	Oil paint, vehicle oil, modified oils, pigments, toners, thinners, enamels, and emulsifying agents.	3
	4.3	Special paints- (heat retardant paint, fire retardant, eco-friendly paint, plastic paint), dyes, wax polishing, water and oil paints, additives, metallic coatings (electrolytic and electroless), metal spraying and anodizing.	3
	4.4	Classification of alloys, Ferrous and non-ferrous alloys, specific properties of elements in alloys.	3
	4.5	Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization, dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing).	3
	4.6	Composition and properties of different types of steels.	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, quizzes, open book exam etc**		**12**
		1. Advancements in metallurgical processes, including emerging technologies and trends in ore concentration, smelting, and surface coating. 2. Principles and applications of hydrometallurgy and electrometallurgy, with case studies illustrating their use in metal extraction and refining. 3. Chemistry and properties of different types of glasses, ceramics, and cements, discussing their manufacturing processes and industrial applications. 4. Production and properties of fertilizers, covering the manufacturing processes of various nitrogenous, phosphatic, and potash fertilizers. 5. Classification and characteristics of alloys, with focus on the composition, properties, and industrial applications of different types of ferrous and non-ferrous alloys.	12

		6. Safety and environmental considerations in metallurgical and chemical industries, including hazard identification and risk assessment. 7. Optimization of fertilizer manufacturing processes, exploring methods for enhancing nutrient efficiency and minimizing environmental impact. 8. Social and economic implications of the use of different materials in construction and manufacturing industries, considering factors like cost, durability, and environmental impact.	

References

1. *Industrial Chemistry* Vol-I E, Stocchi:, Ellis Horwood Ltd. UK.
2. *Elementary Principles of Chemical Processes*, R. M. Felder, R. W. Rousseau:,Wiley Publishers, New Delhi.
3. I*ntroduction to Ceramics*, W. D. Kingery, H. K. Bowen, D. R. Uhlmann, Wiley Publishers, New Delhi
4. *Riegel's Handbook of Industrial Chemistry,* J. A. Kent, CBS Publishers, New Delhi.
5. *Engineering Chemistry*, P. C. Jain, M. Jain, Dhanpat Rai & Sons, Delhi.
6. *Engineering Chemistry*, R. Gopalan, D. Venkappayya, S. Nagarajan: Vikas Publications, New Delhi.
7. *Engineering Chemistry*, B. K. Sharma: Goel Publishing House, Meerut.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand and utilize various techniques to separate and extract metals from their ores, along with the chemical principles behind these processes.	U, Ap	1,2
CO-2	Gain sound knowledge of inorganic materials like silicates, ceramics and cement.	U	1,2
CO-3	Understand essential plant nutrients and explore the manufacture of various nitrogenous, phosphatic, and potash fertilizers	U	1,2,3
CO-4	Acquire a comprehensive understanding of surface coatings.	U	1,2,3
CO-5	Comprehend the classification, properties, and manufacturing processes of alloys	An	1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INDUSTRIAL CHEMISTRY-III

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2	U, Ap	C	L	
2	CO-2	1,2	U	C	L	
3	CO-3	1,2,3	U	C	T	
4	CO-4	1,2,3	U	C	L	
5	CO-5	1,2	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	-	-	-	3	3	-	-	-	-	-	-
CO 2	3	2	-	-	-	3	3	-	-	-	-	-	-
CO 3	3	2	1	-	-	3	3	-	-	-	-	-	-
CO 4	3	2	1	-	-	3	3	-	-	-	-	-	-
CO 5	3	3	-	-	-	3	3	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE307**				
Course Title	**INDUSTRIAL CHEMISTRY - IV**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK3DSECHE 203 UK4DSECHE 203				
Course Summary	This course offers a comprehensive understanding of environmental science, focusing on the various components of the environment, pollution, its effects, and mitigation measures.				

Detailed Syllabus:

Module	Unit	Content **INDUSTRIAL CHEMISTRY - IV**	Hrs
I	**ENVIRONMENT**		**9**
	1.1	Environment segments -lithosphere, hydrosphere, biosphere, atmosphere	2
	1.2	Structure and composition of the atmosphere, temperature profile diagram on major atmospheric regions	2
	1.3	Chemical species and particulates present in the atmosphere -ions, radicals, particles.	2
	1.4	Hydrosphere-chemical composition of water bodies-ground water, river and lake water, seawater, hydrological cycle.	3
II	**AIR POLLUTION**		**9**
	2.1	Pollutant - definition, and classification of air pollutants -based on origin, source, chemical composition, and states of matter.	3
	2.2	Air pollutants and their adverse effect on humans, and plants -oxides of carbon (CO, CO_2), Oxides of Nitrogen, oxides of sulphur, hydrocarbon, particulates, persistent pollutants and non-persistence pollutants.	3
	2.3	Impact of air pollutants on human health, plants and materials, Cause and consequence of Acid rain, photochemical smog, Ozone depletion, greenhouse effect, Global warming.	3
III	**CONTROL AND MONITORING OF AIR POLLUTION**		**9**

	3.1	Air pollution control method- principle and working of gravitational settling chamber, catalytic converter, wet scrubber, fabric filters and electrostatic precipitator.	3
	3.2	Cyclone collector, zoning and green belts, control of gaseous pollutants through adsorption, absorption, cold trapping	3
	3.3	Monitoring of Gaseous pollutants: NO_x-spectrophotometric methods, sulphur dioxide-modified West -Gaeke spectrophotometric method, hydrocarbons-gas chromatographic method	3
IV	**WATER POLLUTION AND WATER QUALITY PARAMETERS**		**18**
	4.1	Importance of water, self-purification capacity of the water body, visible signs of water pollution, Sources of water pollution.	2
	4.2	Classification of water pollutant-organic waste, oxygen-demanding waste, disease-causing waste, synthetic organic waste, sewage and agricultural run-off.	2
	4.3	Oil pollution, inorganic pollutants, suspended solids and sediments, radioactive material, heat and pesticides.	2
	4.4	Effects of water pollution-Eutrophication-biomagnification, bioaccumulation, Characteristic of wastewater- physical, chemical, biological.	3
	4.5	Measurement of water quality parameters: sampling and analysis for pH, Conductivity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD)	3
	4.6	The hardness of water- temporary and permanent, methods for removal of hardness of water.	3
	4.7	Domestic water treatment-sewage treatment	3
V	**PRACTICALS** **A minimum of five practicals from any two sections must be performed and reported**		**30**
	5.1	**SECTION A** 1. Estimation of total hardness of Water 2. Estimation of temporary and permanent hardness 3. pH and conductance of water samples.	**10**
	5.2	**SECTION B** 4. Determination of alkalinity of water samples 5. Estimation of Dissolved Oxygen (DO) in water samples (Winkler Method) 6. Estimation of Biochemical Oxygen Demand (BOD)in water samples 7. Estimation of Chemical Oxygen Demand (COD) in water samples	**10**
	5.3	**SECTION C** 8. Estimation of chloride in water samples 9. Estimation of sulphate in water samples 10. Estimation of total nitrogen content in water	**10**

References

1. *Environmental Chemistry*: H Kaur, Fifth edn.
2. *Environmental Chemistry*: V.K.Ahluwalia,
3. *Textbook of Environmental Chemistry*: Balram Pani, I.K. International.
4. *A Text Book of Environmental Chemistry and Pollution Control*: S .S.Dara..
5. *Environmental Chemistry:* A.K.De.
6. *Environmental Chemistry*: B.K Sharma.
7. *Essentials of Environmental Studies*: S.P. Misra and S.N Pandey.
8. *Engineering Chemistry*:Jain and Jain, Dhanpat Rai Publishing company.
9. *Vogel's Textbook Quantitative Chemical Analysis*: G.H. Jeffery, J.Bassett, J.Mendham, R.C.Denney.
10. *Water pollution*: V.P.Kudesia, seventh edn.
11. *Engineering Chemistry* R.V.Gadag, A.Nityananda Shetty.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the different segments and composition of the environment and hydrosphere.	U	1,2
CO-2	Understand the types, sources, and impacts of air pollutants on human health, plants, and the climate.	U	1,2,3
CO-3	Learn air pollution control methods and techniques for monitoring different gaseous and particulate pollutants.	U	1,2
CO-4	Identify the sources and classifications of water pollutants and their impacts on aquatic ecosystems.	An	1,2,3
CO-5	Gain an understanding of key water quality parameters and methods for their measurement.	U	1,2
CO-6	Understand and perform various analytical techniques for water quality assessment	E	1,2,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INDUSTRIAL CHEMISTRY-IV

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2	U	C	L	
2	CO-2	1,2	U	C	L	
3	CO-3	1,2,3	An	C	L	
4	CO-4	1,2,5	U	C	L	
5	CO-5	1,2,5	E	P	T	
6	CO-6	1,2,5	U	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	3	-	-	-	3	3	-	-		-		
CO 2	1	3	2	-	-	3	3	-	-	-	-	-	-
CO 3	1	2	-	-	-	3	3	-	-	-	-	-	-
CO 4	1	3	2	-	-	3	3	-	-	-	-	-	-
CO 5	1	3	-	-	3	3	3	-	-	-	-	-	-
CO 6	3	2	-	-	3	3	3	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5		✓		
CO 6		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE308**				
Course Title	**POLYMER CHEMISTRY-III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Prior knowledge of polymers in various fields 2. UK3DSECHE204, UK4DSECHE204				
Course Summary	"Polymers in Industry" offers an in-depth exploration of the wide-ranging applications of polymers across various industrial sectors. it includes practical experiments in Polymer analysis and preparation and providing students with hands-on experience in the laboratory.				

Module	Unit	Content POLYMER CHEMISTRY-III	Hrs 60
I	**CHARACTERIZATION TECHNIQUES OF POLYMERS**		**12**
	1.1	Preliminary analysis: solubility, flame test, Lassaigne's test, heating test and melting point test (LDPE and HDPE). Analysis of polystyrene (dye test).	2
	1.2	Molecular weight (mention any two methods only). Physical properties: stress-strain behavior in tension, fatigue, impact strength, tear resistance	2
	1.3	Optical properties – transmittance, reflectance; electrical properties – dielectric strength (no experimental details and method of determination).	2
	2.1	Applications of IR, NMR (proton and C-13) and X-ray diffraction in characterization.	2
	2.2	Thermal analysis, Differential Thermal analysis and Thermogravimetric analysis in characterization of Polymers	2
	2.3	Differential scanning caloroimetry in characterization of Polymers.	2
II	**POLYMERS IN FIBER INDUSTRY**		**9**
	1.1	Harvesting, extraction, processing, and characteristics of natural fibers (cotton, wool, silk, jute, flax).	1
	1.2	Application and uses of natural fibers in textiles. Regenerated cellulose fibers-viscose, tencel, cellulose acetate and triacetate (Mention only)	2

	1.3	Polyester, nylon, acrylic, polypropylene, polyethylene, acetate, Lycra and their manufacturing processes. Properties and advantages of synthetic fibers.	2
	1.4	Comparison with natural fibers in terms of properties and applications. Environmental considerations in synthetic fiber production.	2
	1.5	Other fiber forming materials -glass, ceramic, carbon and metal. Innovations in fiber technology. Sustainable practices in textile fibers.	2
III	**POLYMERS IN ADHESIVES COATING**		**9**
	2.1	Adhesives-adhesive bonding, advantages-adhesive classification basic terminology, theories of adhesion-wettability	1
	2.2	Performance of adhesives - shear, peel and cleavage properties, factors affecting adhesive performance	2
	2.3	Design of adhesive joints, selection of adhesives. Structural adhesive, types - epoxy, urethane, acrylic, phenolic and high temperature and PVC plastisol types	2
	2.4	Advantages and disadvantages, anaerobic adhesives, cyanoacrylates, hot melt adhesive, pressure sensitive adhesives, silicone adhesives, water-based adhesives, inorganic adhesives.	1
	2.5	Pigments and paints, inorganic pigments & organic pigments, extenders paint preparation factors affecting dispersion, preparation of pigment dispersion-	1
	2.6	Surface preparation and paint application techniques. Paint properties and their evaluation, mechanism of film formation factors affecting coating properties, methods used for film preparation, Carrier properties, optical properties, ageing properties, rheological properties and adhesion properties of coatings.	2
IV	**POLYMERS IN PACKAGING, BIOMEDICAL AND AEROSPACE APPLICATIONS**		**18**
	4.1	Edible and biobased food packaging materials, Edible film and coating, Polysaccharide based coatings, Lipid based coatings, Protein based coating, First, Second and Third biobased packaging materials.	4
	4.2	Permeability of thermoplastic polymers, Deteriorative reaction in foods, Enzyme reactions, Chemical reactions,	3
	4.3	Physical change, Biological change, shelf life of foods, Factors controlling shelf life.	1
	4.4	Packaging of dairy products, Packaging of cereals, snack foods and confectionary, Packaging of beverages, Comparison of polymer packaging with paper, metal and glass materials	2
	4.5	Definition of Biomedical Polymers and its classification, Criteria for the Selection of Biomedical Polymers Properties of biomedical Polymers, Polymers for biomedical applications– Polymers in dentistry, Polymers in Tissue adhesives, Dialysis Membrane	3
	4.6	Polymers in Blood oxygenators, Bone cement, Prostheses, Polymers in Biodegradable sutures, Control drug delivery systems	2

	4.7	Various application of polymers in aerospace, Requirement of polymer characteristics for in-space usage, polymers in aerospace applications: thermal blanket, helmet, adhesive, Space Suits,	3
V	**Open Ended Module: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
	1	Research and write a report on polymers in fiber industry focusing on sustainable practices in textile fibers.	
	2	Discuss the importance of Environmental considerations in synthetic fiber production.	
	3	Explore the principles of Surface preparation and paint application techniques.	
	4	Discuss the feasibility and practicality of implementing green strategies in the paint industry.	
	5	Propose greener alternatives or modifications to the packaging of dairy products, packaging of cereals, snack foods and confectionary, packaging of beverages etc. **(Or any other related activities introduced by the teacher)**	

References

1. W. E. Morton and J. W. S. Hearle, *Physical properties of Textile Fibers*,4th edn , Woodhead publishing Ltd ,2008.
2. S. P. Mishra, *A text book of Fibres Science and technology*, New Age International (p) Ltd, 2000.
3. Dr. V.A. Shenai, *Textile Fibres – Volume 1 of Technology of textile processing*, Sevak Publications, 1971.
4. Menachem Lewin, *Handbook of Fiber Chemistry*, 3rd Edition, CRC Press 2006.
5. J.E. Booth, *Principles of Textile Testing*, CBS PUBLISHERS AND DISTRIBUTORS, 2018, ISBN-: 978-8123905150.
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7. W. C. Wake, *Adhesion and the formulation of adhesives*, Applied Science Publishers, London (1976) https://doi.org/10.1002/pi.4980090118
8. Swaraj Paul, *Surface coatings*, John Wiley & Sons, 2nd edn, 1985, ISBN: 978-0-471-95818
9. Gordon. L Robertson, *Food Packaging*, Taylor and Francis publication, 2006.
10. R J Hernandez, Susan EM Selhe and John D Caller, Plastics *packaging* Hanser Publishers,2000. ISBN: 1569903034, 9781569903032

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Preliminary analysis and advanced characterization techniques to evaluate the physical, chemical, and thermal properties of polymers	R, U, Ap	PSO-1,2
CO-2	Familiar with basic terminology related to adhesives and will explore theories of adhesion and develop a comprehensive understanding of pigments and paints, including their composition, properties, and applications and about choosing of paints.	U, Ap, An	PSO-1,3
CO-3	Develop a comprehensive understanding of food packaging materials, including conventional materials (e.g., plastics, metals, glass) and emerging edible and biobased materials.	R, U	PSO-1,3,8
CO-4	Understanding of the properties of polymers relevant to aerospace applications, including mechanical properties (e.g., strength, stiffness, toughness), thermal properties (e.g., heat resistance, thermal expansion), chemical resistance, and durability in harsh environments (e.g., UV radiation, moisture, space vacuum).	R, U, Ap	PSO-1,2
CO-5	Develop critical thinking skills and a comprehensive understanding of the principles and techniques used in polymer characterization, as well as the diverse applications of polymers	An, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyze, E-Evaluate, C-Create

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO-1	1/1,2	R, U, Ap	F, P	L	
2	CO-2	4/1,3	U, Ap, An	F, M	L	
3	CO-3	7/1,3,8	R, U	F, C	L	
4	CO-4	1/1,2	R, U, Ap	C	L	
5	CO-5	1,2,6/1,2,3,4,5	An, E	P	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO 2	PSO 3	PSO 4	PSO 5	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	-	-	-	3	2	-	-	-	-	-	-
CO 2	3	-	1	3	-	-	-	-	-	3	-	-	-
CO 3	1	-	2	-	2	-	-	-	-	-	2	-	-
CO 4	3	2	-	-	-	2	3	-	-	-	-	-	-
CO 5	3	2	1	1	2	2	3	-	-	-	3	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	

University of Kerala

Discipline	CHEMISTRY
Course Code	**UK5DSECHE309**
Course Title	**POLYMER CHEMISTRY IV**
Type of Course	**DSE**
Semester	5
Academic Level	300 – 399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Pre-requisites	1. Basic knowledge about the plastics and fibres. 2. UK3DSECHE204, UK4DSECHE204, UK5DSECHE308
Course Summary	To impart the basic concepts of Mixing and compounding various moulding techniques. Understand about reinforced plastics and fiber technology. it includes practical experiments in Plastic and Fibre Technology and providing students with hands-on experience in the laboratory.

Detailed Syllabus:

Module	Unit	Content POLYMER CHEMISTRY IV	Hrs 75
I	**MIXING AND COMPOUNDING**		**9**
	1.1	Introduction to plastic processing, additives for plastics – Fillers, Antioxidants	1
	1.2	Stabilisers, Colourants, Flame retardants	2
	1.3	Plasticisers. Mixing and compounding of plastics	2
	1.4	Mixing and compounding equipments- Compounding by batch mixer	2
	1.5	High speed mixer - Two roll mill - Banbury Mixer - Ribbon blender - Planetary mixers	2
II	**MOULDING TECHNIQUES I**		**9**
	2.1	Plastic injection moulding, different types of injection moulding machines	1
	2.2	Details of injection moulding machine, injection moulding of thermosets.	2
	2.3	Extrusion, details of extruders, twin screw extruders, dies, post extrusion processing	2
	2.4	Calendaring. Laminating	2
	2.5	3D printing.	2
III	**MOULDING TECHNIQUE II**		**9**

	3.1	Compression moulding: hydraulic presses, press capacity and pressure calculations, moulding process.	1
	3.2	Transfer moulding: moulding process and advantages	2
	3.3	Blow moulding: extrusion and injection blow moulding.	2
	3.4	Rotational moulding: process and equipment.	2
	3.5	Reaction injection moulding: introduction, process and advantages.	2
IV	**Reinforced plastics & Fiber technology**		**18**
	4.1	Reinforced plastics, Processing techniques	3
	4.2	Hand lay-up, spray lay-up, filament winding autoclave	4
	4.3	Bag moulding	2
	4.4	Fibers from cellulose and its derivatives, polyolefinic, polyester, polyamide, aramide.	3
	4.5	Carbon and glass fibers, Fiber spinning operations	2
	4.6	Different types of cords used in tyre industry, definition of denier, tex, tenacity	2
	4.7	Different types of twisting, geo textiles	2
V	**PLASTICS AND FIBRE TECHNOLOGY PRACTICALS**		**30**
	1	1. Hands on training in production of injection moulded plastic articles 2. Hands on training in production of blow moulded plastic articles 3. Hands on training in production of compression moulded plastic articles 4. Hands on training in production of injection moulded plastic articles 5. Case study on variation in properties of molded Polymer products by varying different additives 6. Case study on variation in properties of reinforced plastics products by varying different reinforcing methods 7. Case study based on fibre technology-based industries.	

References

1. C. J. Crawford, *Plastic Engineering*, Pergamon Press, London ,1999.
2. D. H. Morton, *Polymer processing*, Chapman and Hall, London, 1989.
3. George Mathews, *Polymer mixing technology*, Applied Science Publishers, London, 1982.
4. Joel Frados (Ed) *Plastic Engineering Hand book*, Van Nostrand Reinhold Company, New York, 1976.
5. Joel Fried, *Polymer Science and Technology*,2nd Edn. Prentice Hall of India Ltd, 2003.
6. Fred W BillMeyer, JR. Wiley, *Text Book of Polymer Science*, 3rd Edn, 1984.
7. VR Gowariker, NV Viswanathan, Jayadev Sreedhar, Polymer Science, 3rd Edn. New Age International Publishers, 1996.
8. Dr BK Sharma, *Polymer Chemistry*, Goel Publishing House,2014.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the basics of plastic processing and the role of additives in plastics. Describing the techniques used and compounding equipment used in the industry	U	PSO-1,2
CO-2	Explain the principles, processes and machines involved in plastic injection molding Analyze the principles of calendering, laminating, and 3D printing in plastic processing	An	PSO-1,2
CO-3	Understand the principles and processes involved in various molding like compression molding, transfer molding, blow molding, rotational molding, and reaction injection molding and their advantages	U	PSO-1,3
CO-4	Explain the concept of reinforced plastics and the materials processing techniques, identify different types of fibers used in industries and different fiber spinning operations.	R, U, An	PSO-1,2,3
CO-5	Hands on training in production of moulded plastic articles using various moulding techniques and a case study	Ap	PSO-4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Crea

Name of the Course: POLYMER CHEMISTRY IV

Credits: 3:0:1(Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	**1/1,2**	U	F, C	L	
2	CO-2	**3/1,2**	An	F	L	
3	CO-3	**1/1,3**	U	C	L	
4	CO-4	**7/1,2,3**	R, U, An	F, C	L	
5	CO-5	2,3/4	Ap	p		p

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	-	-	-	2	-	-	-	-	-	-	-
CO 2	1	2	-	-	-	-	-	3	-	-	-	-	-
CO 3	3	-	2	-	-	2	-	-	-	-	-	-	-
CO 4	2	2	3	-	-	-	-	-	-	-	-	3	-
CO 5	-	-	-	3	-	-	2	-	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE310**				
Course Title	**FORENSIC CHEMISTRY III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Basic understanding of Crime Scene and Management and role of police in forensic Science 2. Fundamental Knowledge in Forensic Science, Techniques and technologies 3. UK3DSECHE205, UK4DSECHE205				
Course Summary	Forensic Chemistry, Petroleum products in Forensic samples, Narcotic drugs and Psychotropic substances, Forensic Explosives, Forensic Toxicology				

Detailed Syllabus:

Module	Unit	Content **FORENSIC CHEMISTRY III**	Hrs **60**
I	**FORENSIC CHEMISTRY**		**9**
	1.1	Introductionto Forensic chemistry, sampling of chemical evidences, presumptive, screening (colour/ spot test), inorganic analysis	2
	1.2	Detective dyes- cases and importance in trap cases. Arson Chemistry of fire, searching of fire scene, collection, preservation and examination of arson evidences.	2
	1.3	Adulteration in Petroleum products. Examination procedures involving standard methods and instrumental techniques, analysis of beverages- alcoholic and non-alcoholic, country made liquor and medicinal preparations containing alcohol as constituents	3
	1.4	Significance of alcohol in breath and breath screening devices. Forensic analysis of Fertilizers/ insecticides/ pesticides/ biocides. (All basic principles only)	2
II	**CHEMISTRY OF FORENSIC EXPLOSIVES**		**18**
	2.1	Introduction, Definition, Classification of Petroleum Products. Examination of Petroleum Products: distillation and fractionation, various	3

		fractions and their commercial uses, standard methods of analysis of petroleum products in Forensic Samples-Various Parameters	
	2.2	Chemistry of fire, Origin and Cause of Fire, Types of Ignitable Liquids, Fire and Arson- definition- Forensic Investigation of Fire and Arson Scenes, evaluation of clue material, analysis of Fire and Arson samples by Instrumental Methods	3
	2.3	Definition and scope of forensic explosives analysis- Historical background- Importance in forensic investigations	2
	2.4	Introduction to various types of explosives -Classification of Explosives-Chemical structure composition and characteristics of each type- Synthesis and characteristics of TNT, PETN and RDX. Explosion process	3
	2.5	Blast waves. Bomb scene management. Searching the scene of explosion-Key chemical and physical properties of explosives-Safety precautions in handling explosive material	3
	2.6	Effects of Explosion- Overview of analytical techniques used in forensic explosives analysis (e.g., chromatography, spectroscopy, microscopy)	2
	2.7	Protocol for examining post-blast scenes- Collection and preservation of evidence-Role of explosives residues in investigation.	2
III	**FORENSICS OF NARCOTIC DRUGS AND PSYCHOTROPIC SUBSTANCES**		**12**
	3.1	Narcotics, Drugs and Psychotropic Substances - Definition of narcotics, drugs, and psychotropic substances	2
	3.2	Broad classification – Narcotics, stimulants, depressants and hallucinogens.	2
	3.3	General characteristics and common example of each classification	3
	3.4	Natural, synthetic and semi-synthetic narcotics, drugs and psychotropic substances - Designer drugs.	3
	3.5	Tolerance, addiction and withdrawal symptoms of narcotics, drugs and psychotropic substances	2
IV	**FORENSIC TOXICOLOGY**		**9**
	4.1	Definition and scope of forensic toxicology- Historical background and development-Basic Principles of Toxicology-Definition, classification of poisons- organic, inorganic, metallic, non-metallic etc	3
	4.2	Acute and chronic poisoning, Accidental, homicidal and suicidal poisoning, Extraction and identification of commonly used poisons	3
	4.3	Factors influencing toxicity-Dosage, Frequency, Route of administration, Absorption, distribution and metabolism and factors affecting metabolism and excretion.	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
		1. Seminars or interaction with officials from Antinarcotics 2. Debate on abuse of drugs and their role in crime 3. Assignment on different explosives in Crime 4. Discussion on drugs and crime	

References

1. Teotia, A.K. and Pal, R. *Practical Aspects of Forensic Chemistry.* Selective & Scientific Books: New Delhi; (2013).
2. Lundquist, F. and Curry, A.S. *Methods of Forensic Science. Inderscience* Publisher: California; (1963).
3. *Laboratory Procedure Manual: Petroleum Products,* Directorate of Forensic Science, MHA, Govt. of India, 2005
4. Jitrin, Y. *Modern Methods & Application in Analysis of Explosives*. John Wiley & Sons: England; (1993).
5. *Working Procedure Manual; Chemistry, Explosives and Narcotics*, BPR&D Publications: New Delhi; (2000).
6. Clarke, E.G.C. and Moffat, A.C. Clarke's *Isolation and Identification of Drugs: In Pharmaceuticals, Body Fluids and Post Mortem Material*. Pharmaceutical Press: (1986).
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8. Jickells, S. and Negrusz, A. *Clarke's Analytical Forensic Toxicology*. Pharmaceutical Press: (2008).
9. Niesink, RJM; *Toxicology- Principles and Applications*, CRC Press,1996
10. Modi, JP, *Textbook of Medical Jurisprudence & Toxicology*, N.M. Tripathi Pub,2001
11. Chadha, PV; *Handbook of Forensic Medicine & Toxicology*, Jaypee Brothers, New Delhi,2004
12. *Working Procedure Manual on Chemistry*; Directorate of Forensic Science MHA Govt. of India

Course Outcomes

SI No	Course Outcome: Upon completion of this course the student will be able to	Cognitive Level	PSO
CO-1	Identify the role chemistry and its basic knowledge in Forensic Science	An	2
CO-2	Measure the role of explosives in crime	E	4
CO-3	Distinguish the hazardous drugs and their symptoms	U	2
CO-4	Recognize the basics of forensic Toxicology and principles	R	3
CO-5	Interpret the role of drugs, explosives in present day crime	U	4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FORENSIC CHEMISTRY III

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)

1	CO-1	2	An	C	L	
2	CO-2	4	E	F, C	L	
3	CO-3	2	U	F, C, P	L	
4	CO-4	3	R	F, C, P	L	
5	CO-5	4	U	F, C, P, M	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	2	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	-	-	-	-	-	-	-	-	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE311**				
Course Title	**FORENSIC CHEMISTRY IV**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge in Forensic Chemistry and also chemistry of materials 2. Understanding on Narcotic drugs and forensic Toxicology 3. UK3DSECHE205, UK4DSECHE205, UK5DSECHE310				
Course Summary	Spectroscopy Techniques**:** UV-Vis, IR, NMR, Mass, AAS and Raman Principle, Procedure and application and analytical Techniques				

Detailed Syllabus:

Module	Unit	Content **SPECTROSCOPIC AND ANALYTICAL TECHNIQUES**	Hrs 75
I	**UV-Visible, IR Spectroscopy**		**9**
	1.1	Spectroscopy, Electromagnetic Radiation, Phenomena of Emission, Absorption, Reflection, Introduction to UV-visible and fluorescence spectroscopy, Beer and Lambert's law.	2
	1.2	Different types of electronic transitions, Auxochrome, chromophore, Absorption and intensity shift.	1
	1.3	Introduction, Principle of IR spectroscopy, vibrational frequency, number of fundamental vibrations, selection rules, factors influencing vibrational frequency, finger print region	3
	1.4	Application of IR spectroscopy in forensic science Application of UV-visible and IR spectroscopy in forensic science	3
II	**Nuclear Magnetic Resonance and Mass Spectroscopy**		**15**
	2.1	Introduction, Relaxation process, Number of signals, position of signal, chemical shift, internal standard, shielding and deshielding effects,	3
	2.2	Factors influencing chemical shift solvents used, splitting of signals, spin-spin coupling, coupling constant	3
	2.3	Basic principles, theory, Mc Lafferty rearrangement, molecular ion peak and base peak, GCMS, LCMS,	3

	2.4	Secondary Mass Spectrometry Laser Mass spectrometry, Fast Atom bombardment and liquid secondary Ion Mass spectrometry,	2
	2.5	High performance liquid chromatography, Electrospray Ionization mass spectrometry.	2
	2.6	Application of these techniques in forensic science	2
III	**Absorption Spectrometry and Raman Spectroscopy**		**9**
	3.1	Atomic absorption spectrometry: Introduction, Instrumentation and techniques, interference in AAS, background correction methods, quantitative analysis. Application of AAS in forensic science	3
	3.2	Raman spectroscopy: Introduction, Quantum theory of Raman effect, Theory of Raman spectra (Stoke's and anistoke's lines), conditions for Raman spectroscopy, Raman spectra of diatomic molecules, Application of Raman spectroscopy in forensic science	3
	3.3	Fluorescence spectrometry: Basics of Fluorescence and Phosphorescence spectrophotometry and its application in forensic science	3
IV	**Analytical Techniques Forensic Toxicology**		**12**
	4.1	Definition and scope of analytical toxicology- Importance in various fields including forensic science, clinical toxicology, and environmental monitoring- Acute and Chronic poisons	3
	4.2	Collection and Preservation of Specimens- Techniques for collecting biological specimens (blood, urine, tissues)- Preservation methods to maintain sample integrity	3
	4.3	Principles of separation and detection- common analytical techniques used in toxicology (chromatography, spectroscopy, immunoassays, etc.)	2
	4.4	Selection criteria for analytical methods based on sample type and analyte properties, TLC, GC, HPLC, LC and MS techniques	2
	4.5	Detection of Toxic metals, chemicals pesticides, herbicides, and toxic gases with special reference to common poisons - Review of real-world cases involving forensic toxicology analysis	2
V	**PRACTICALS:**		**30**
		1. IR spectral analysis of functional groups like hydroxyl group, carbonyl group, amino group etc. 2. Identify drug samples using UV 3. To determine the concentration of a colored compound by colorimetric analysis (verify Beer Lambertz law and determine the concentration of $CuSO_4$, $KMnO_4$ and $K_2Cr_2O_7$ 4. To determine refractive index of liquids. 5. Determination of poisonous metals in biological materials by AAS.	

References

1. Robinson, J.W; *Atomic Spectroscopy*, 2nd Ed. Revised & Expanded, Marcel Dekkar, Inc, New York, 1996.

2. Workman, J; Art Springsteen; *Applied Spectroscopy- A compact reference for Practitioners,* Academic Press, London, 1997
3. Willard, H.H. Lynne L. Merrett, J. Dean, A. Frank, A. Settle. J; *Instrumental Methods of Analysis,* 7th Edn.CBS pub.& Distributors, New Delhi, 1986.
4. Khandpur, R. S; *Handbook of Analytical Instruments*, Tata McGraw Hill Pub. Co.New Delhi, 2004
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6. Dudley, H. Williams & Fleming, I; *Spectroscopic Methods in Organic Chemistry*, 4th Edn, Tata McGraw- Hill Publishing Company, New Delhi, 1994.
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8. W. Kemp, *Organic Spectroscopy*, 3rd Edition, Macmillan, Hampshire (1991).
9. J.W. Robinson, *Undergraduate Instrumental Analysis*, 5th Edition, Marcel Dekker, Inc., New York (1995).
10. Workman, J; Art Springsteen; *Applied Spectroscopy- A compact reference for Practitioners*, Academic Press, London, 1997
11. Dudley, H. Williams & Fleming, I; *Spectroscopic Methods in Organic Chemistry*, 4th Edn, Tata McGraw- Hill Publishing Company, New Delhi, 1994

Course Outcomes

SI No	Course Outcome: Upon completion of this course the student will be able to	Cognitive Level	PSO
CO-1	Describe the characterization techniques involved in the Forensic Science	R	1,2
CO-2	Interpret the different spectra available for investigation	U	2
CO-3	Explain the role of different instruments in investigation	Ap	2,3
CO-4	Summarize the analytical techniques involved in forensic science	U	2
CO-5	Distinguish the analytical and spectral techniques in Forensic Chemistry	An	2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FORENSIC CHEMISTRY IV

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)

1	CO-1	1, 2	R	C	L	
2	CO-2	2	U	F, C	L	
3	CO-3	2,3	Ap	F, C, P	L	
4	CO-4	2	U	F, C, P	L	
5	CO-5	2,3	An	F, C, P, M	L/T	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	2	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	2	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	-	-	-	-	-	-	-	-	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE312**				
Course Title	**CHEMISTRY OF NANOMATERIALS-III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Essential basic knowledge in structure of atoms, periodic properties and general properties of bulk materials such as metals and non-metals. 2. Elementary knowledge in the basic principles of quantum mechanics, quantum confinement effect, application of Schrodinger wave equation to simple solvable systems like particle in 1-D box, 3-D box. Necessary mathematical skills and numerical ability. 3. UK3DSECHE206, UK4DSECHE206				
Course Summary	The principal objective of this course is to provide necessary and sufficient knowledge in the basic aspects of highly emerging area of nanomaterials and to develop genuine interest in that field. This course aims to provide pertinent information related to the evolution of nanomaterial science as a new branch of science, the size dependent properties of the nanomaterials, synthesis of nanomaterials by various methods such as top-down and bottom-up methods as well as to give sufficient knowledge regarding basic characteristic features of metal nanoparticles.				

Detailed Syllabus:

Module	Unit	Course Description CHEMISTRY OF NANOMATERIALS -III	Hrs 60
I	**EVOLUTION OF NANOMATERIAL SCIENCE**		**9**
	1.1	History of Nanotechnology, Medicinal Preparations with Nanogold (elementary idea), Faradays divided metal- preparation, physical properties, Lycurgus cup- composition, comparison with ordinary, glass dichroism, Ancient stained glass	3
	1.2	Properties of Nanomaterials, Comparison of bulk materials with nanomaterials, Quantum confinement effect-explanation based on particle in 1D- box and 3D-box problem, Surface to volume ratio- effect in nanomaterials and bulk materials	3

	1.3	Nanosystems in nature- existence of nanosized materials and their effect in Lotus leaf, Gecko's feet, Shark skin, Toucan beaks, Butterfly wings, Spider silk and Peacock feather, Superhydrophobicity, Introduction to biomimetics, Nanotechnology vs nanoscience	3
II	**CLASSIFICATION AND SIZE DEPENDENT PROPERTIES OF NANOMATERIALS**		**9**
	2.1	Classification of nanostructured materials based on quantum confinement, Degrees of freedom and Degree of Confinement, The zero dimensional (0-D), one dimensional (1-D), two dimensional (2-D) and three dimensional (3-D) nanostructured materials	3
	2.2	Characteristic features of 0-D, 1-D, 2-D and 3-D nanostructured materials, Quantum Well, Quantum Wire Quantum Dot, Thin films	3
	2.3	Exciton, Exciton Bohr radius and quantum confinement, Quantum confinement and energy levels of nanostructures, Band gap, Size and Bandgap in nanomaterials, Density of States (DoS), Plot of DoS against energy for different quantum structures (Quantum Well, Quantum Wire Quantum Dot)	3
III	**SYNTHESIS OF NANOMATERIALS: TOP-DOWN AND BOTTOM-UP METHODS**		**18**
	3.1	Introduction to nanomaterial synthesis, Two synthetic approaches: Top-down and bottom-up approaches	1
	3.2	RF Plasma method- Principle, instrumentation and process Thermolysis method, High energy ball milling method -factors determining the energy transfer from high energy balls to materials, advantages	2
	3.3	Laser ablation method- principle, pulsed wave and continuous wave laser ablation, instrumentation, advantages and disadvantages of laser ablation method	2
	3.4	Nanolithography, Different types nanolithography- Electron Beam Lithography, Photolithography and Nanoimprint lithography (basic principles and elementary idea), Sputtering method, Advantages and disadvantages of top-down methods	3
	3.5	General idea of Bottom-up approach, Chemical reduction- usage of reducing agents like sodium borohydride, ascorbic acid etc. in the synthesis of metal nanoparticles	2
	3.6	Chemical Vapour Deposition (CVD)- principle, precursors used in CVD, instrumentation, advantages, Sol-gel synthesis-different stages, advantages	2
	3.7	Hydrothermal synthesis- principle, hydrothermal autoclave and its parts, advantages of hydrothermal method, Co-precipitation method, preparation of iron oxide nanoparticles by co-precipitation method, Spray pyrolysis method- principle and process	3
	3.8	Electrodeposition method- principle, factors influencing electrodeposition, Molecular Beam Epitaxy- principle,	3

		instrumentation and process, Advantages and disadvantages of bottom-up methods	
IV	**METAL NANOPARTICLES**		**9**
	4.1	Main characteristics of metal nanoparticles (MNPs), General methods of preparation- chemical and physical methods, Stability of MNPs- role of capping agents, common capping agents used in the synthesis of MNPs.	3
	4.2	Gold nanoparticles (Au NPs): Synthesis by different methods such as Turkevich method, Brust–Schiffrin method, properties and applications of Au NPs	2
	4.3	Optical and Electronic Properties: Surface plasmon Resonance (SPR), Colour of gold nanoparticles and SPR	1
	4.4	Silver nanoparticles (Ag NPs): Synthesis by different methods, properties, size tuneable colour, different morphologies of Ag NPs, morphology and SPR, Applications of Ag NPs- antibacterial properties, water purification, other applications	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, quizzes, open book exam etc.**		**12**
		1. History of Nanotechnology, Medicinal Preparations with Nanogold. 2. Lycurgus cup- composition, comparison with ordinary glass. 3. Classification of nanostructured materials based on quantum confinement 4. Quantum Well, Quantum Wire Quantum Dot, Thin films 5. Plot of DoS against energy for different quantum structures 6. Top-down and bottom-up approaches, advantages and disadvantages 7. Nanolithography, different types of nanolithography 8. Metal nanoparticles, synthesis and stability 9. Gold nano particles-synthesis and applications 10. Silver nano particles-synthesis and applications	

References:

1. Hornyak, G. L., Tibbals, H. F., Dutta, J and Moore, J. J. (2008), *Introduction to Nanoscience and Nanotechnology*, CRC Press.
2. Pradeep, T. (2007), *NANO: The Essentials: Understanding Nanoscience and Nanotechnology*, McGraw Hill.
3. Poole, C. P and Owens, F. J. (2003), *Introduction to nanotechnology*, Wiley Interscience.
4. Binns, C. (2010), *Introduction to Nanoscience and Nanotechnology*, John Wiley and Sons.
5. Rogers, B., Pennathur, S., & Adams, J. (2017), *Nanotechnology: Understanding Small Systems*, CRC Press.
6. Benyus, J. M. (2002), *Biomimicry: Innovation Inspired by Nature*, Harper Collins

7. Kulkarni, S. K. (2015), *Nanotechnology: Principles and Practices,* Springer.
8. Fedlheim, D. L and Foss, C. A. (2001), *Metal Nanoparticles Synthesis, Characterization, and Applications*, Taylor & Francis
9. Irby, V and Saylor, Y. (2018), *Metal Nanoparticles Properties, Synthesis and Applications*, Nova Science Publishers
10. Vollath, D (2013), *Nanomaterials: An Introduction to Synthesis, Properties and Applications*, Wiley VCH

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the historical context of nanotechnology, demonstrate knowledge of the historical evolution of nanotechnology, including key milestones such as Faraday's divided metal and the unique properties of artifacts like the Lycurgus cup and enabling comparisons with conventional materials	R, U	1,3
CO-2	Analyse quantum confinement effects (QCE) in nanomaterials, explain the QCE through models like particle-in-a-box and its impact on the physical properties of nanostructured materials compared to bulk counterparts, emphasizing surface-to-volume ratio effects	An	1,3
CO-3	Identify natural nanosystems and biomimetic applications, recognize natural nanosystems in several biological structures and understand their influence on biomimetics	U, Ap	1,3
CO-4	Classify nanostructured materials based on dimensionality, by categorizing materials learners will differentiate characteristics like quantum confinement and degrees of freedom by linking these to material properties	U, An	1,2,3
CO-5	Evaluate synthesis techniques for nanomaterials, assess top-down methods and bottom-up methods regarding principles, advantages and applications	An, E	1,3,5
CO-6	Discuss metal nanoparticles and their synthesis, describe the main characteristics of metal nanoparticles, understand various synthesis techniques for gold and silver nanoparticles, and evaluate their stability and optical properties	U, Ap	1,2,3

CO-7	Apply knowledge to practical applications, apply acquired knowledge to real-world applications such as the synthesis of metal nanoparticles and their utilization in diverse areas	Ap, An	1,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY OF NANOMATERIALS III

Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO 1,3	R, U	F	L	
2	CO-2	1,3	An	C	T	
3	CO-3	1,3	U, Ap	C	T	
4	CO-4	1,2,3	U, An	C	L	
5	CO-5	1,3,5	An,E	C, P	T	
6	CO-6	1,2,3	U,Ap	M	T	
7	CO-7	1,3,5	Ap,An	M	T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	3	-	-	2	-	-	-	-	-	-	-
CO 2	2	-	2	-	-	2	2	-	-	-	-	-	-
CO 3	3	-	1	-	-	3	3	-	-	-	-	-	-
CO 4	2	2	2	-	-	3	3	-	-	-	-	-	-
CO 5	2	-	3	-	2	3	2	-	-	-	-	-	-
CO 6	2	2	2	-	-	3	2	-	-	-	-	-	-
CO7	3	-	2	-	3	3	3	-	-	-	-	-	-

Correlation Levels:-

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓	✓	✓
CO 5	✓		✓	✓
CO 6	✓			✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE313**				
Course Title	**CHEMISTRY OF NANOMATERIALS-IV**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Essential basic knowledge in structure of atoms, periodic properties and general properties of bulk materials such as metals and non-metals. 2. Elementary knowledge in the basic principles of quantum mechanics, quantum confinement effect. 3. Elementary idea about the size properties of nanomaterials 4. UK3DSECHE206, UK4DSECHE206, UK5DSECHE312				
Course Summary	The principal objective of this course is to provide necessary and sufficient understanding of different carbon-based nanostructures their synthesis, features and applications. This course is also intended to provide an insight into the notable features of metal nanoparticles and their applications in diverse fields				

Detailed Syllabus:

Module	Unit	Content CHEMISTRY OF NANOMATERIALS-IV	Hrs 75
I	**FULLERENES AND THEIR DERIVATIVES**		**9**
	1.1	An overview of different carbon-based nanomaterials- Fullerenes, Carbon nanotubes, Graphene and its derivatives, Carbon quantum dots and Nanodiamonds	2
	1.2	Fullerenes- discovery, synthesis, purification, physical and chemical properties, nomenclature, lower and higher fullerenes	3
	1.3	Derivatives of Fullerene- doped fullerenes, endohedral, exohedral and Heterofullerene, Characterization of fullerenes by ^{13}C- NMR spectroscopy	3
	1.4	Applications of fullerenes and their derivatives	1
II	**GRAPHENE AND GRAPHENE OXIDE**		**9**
	2.1	Different allotropes of carbon, Discovery of Graphene, Synthesis of graphene by top-down methods- mechanical and chemical exfoliation, reduction, Synthesis of graphene by bottom-up methods- pyrolysis, epitaxial growth, chemical vapour deposition (CVD)	3

	2.2	Physical properties of graphene, chemical reactions (elementary idea) Factors affecting electronic and optical properties of graphene-defects, impurities, grain boundaries, wrinkles in sheet	2
	2.3	Applications of graphene-energy storage, transistors, water filtration technology, biosensors, solar cells	1
	2.4	Graphene oxide, Synthesis by different methods- Hummer's method and its modification, Brodie method, Hoffmann method, Reduced graphene oxide, Applications graphene oxide	3
III	**CARBON NANOTUBES, CARBON QUANTUM DOTS AND OTHER CARBON NANOSTRUCTURES**		**9**
	3.1	Carbon Nanotubes (CNTs)- discovery, zig-zag arm-chair and chiral CNTs (elementary idea), comparison of single walled and multi walled carbon nanotubes	2
	3.2	Preparation of CNTs- arc-discharge, CVD, laser ablation, flame synthesis, electrochemical synthesis, Purification of CNTs, physical properties and applications of CNTs	3
	3.3	Carbon Quantum Dots (CQDs)-discovery, synthesis by different methods, optical properties, applications of CQDs	3
	3.4	Nanodiamonds (NDs)-synthesis and applications	1
IV	**METAL OXIDE NANOPARTICLES**		**18**
	4.1	General features of metal oxide nanoparticles-size, morphology, stability, general methods of synthesis and characterization	3
	4.2	Synthesis of metal oxide NPs such as TiO_2, ZnO, and $BaTiO_3$ by wet chemical methods, hydrothermal methods, and pyrolytic or high temperature methods, different phases of TiO_2 nanoparticles, luminescence in ZnO nanoparticles	4
	4.3	Iron oxide nanoparticles-different types, synthesis by different methods such as co-precipitation, magnetic properties	2
	4.4	Physical and Chemical Properties of metal oxide NPs	2
	4.5	Band gap in metal oxide NPs-determination of band gap (elementary idea), size and band gap	2
	4.6	Photocatalysis by metal oxide NPs- removal of organic pollutants, dye degradation, photocatalysis and band gap	2
	4.7	Applications of metal oxide nanoparticles-special emphasis to drug delivery, health care, energy harvesting etc. Surface modification of metal nanoparticles for different applications	3
V	**OPEN END MODULE: PRACTICALS II** **A minimum of 5 practical experiments from any sections must be performed and reported.**		**30**
		A. Synthesis of silver nanoparticles by chemical reduction method	
		1. Synthesis of silver nanoparticles by chemical reduction method 2. Synthesis of silver nanoparticles by reduction using plant extracts (green synthesis) 3. Preparation of citrate capped gold nanoparticles by chemical reduction (Turkevich method)	

		4. Green Synthesis of Gold Nanoparticles Using Plant Extracts 5. Electrochemical synthesis of copper nanoparticles	
		B. Synthesis Metal Oxide Nanoparticles	
		1. Microwave-Assisted Synthesis of Iron Oxide Nanoparticles 2. Iron Oxide Nanoparticles by co-precipitation method 3. Synthesis of Zinc Oxide Nanoparticles via Hydrothermal Method 4. Synthesis of Titanium Dioxide Nanoparticles via Sol-Gel Method 5. Synthesis of Aluminium Oxide Nanoparticles via Flame Pyrolysis	
		C. The synthesized nanomaterials can be characterized by methods such as:	
		1. UV-Visible spectroscopy 2. PXRD 3. SEM 4. EDAX 5. AFM 6. DLS 7. PL spectroscopy 8. Zeta potential measurements 9. IR-Spectroscopy 10. HR-TEM 11. Nitrogen sorption analysis 12. XRF 13. AASprPPX 14. ICP-MS 15. Gouy balance 16. SQUID magnetometer 17. VSM analysis 18. Mass Spectroscopy **Use at least 3 characterization methods, which is suitable for the specific type of nanomaterials**	

References:

1. Hornyak, G. L, Tibbals, H. F., Dutta, J and Moore, J. J. (2008), *Introduction to Nanoscience and Nanotechnology.* CRC Press.
2. Pradeep, T. (2007), NANO*: The Essentials: Understanding Nanoscience and Nanotechnology*. McGraw Hill.
3. Poole, C. P and Owens, F. J. (2003), *Introduction to nanotechnology.* Wiley Interscience.
4. Dresselhaus, M. S., Dresselhaus, G. and Eklund, P. C. (1996). *Science of Fullerenes and Carbon Nanotubes Their Properties and Applications*. Elsevier Science
5. Rao, C. N. R., Pati, S. K and Enoki, T (1996). *Graphene And Its Fascinating Attributes*. World Scientific Publishing Company

6. Arnault, J. -C. (2017), *Graphene and It's Fascinating Attributes.* World Scientific Publishing Company.
7. Fabian Ezema, F. and Ahmad, I. (2019). *Graphene and Its Derivatives Synthesis and Applications*. Intech Open/
8. Jelinek, R. (2016). *Carbon Quantum Dots Synthesis, Properties and Applications*. Springer International Publishing.
9. Sung, J. (2019). *Diamond Nanotechnology Synthesis and Applications*. Jenny Stanford Publishing

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Comprehensive understanding of carbon-based nanomaterials, demonstrate an in-depth comprehension of various carbon-based nanomaterials encompassing their discovery, synthesis, physical and chemical properties	U	1,3
CO-2	Apply 13C-NMR spectroscopy for the characterization of fullerenes, understanding its principles and methodologies in analysing different fullerene derivatives and structures	Ap	1,3,5
CO-3	Analyse the synthesis techniques, physical, electronic, and optical properties of graphene and its derivatives, correlating these properties with the material's defects, impurities and grain boundaries, also evaluate their applications in diverse fields	An, E	1,2,3
CO-4	Compare and contrast different carbon nanostructures like carbon nanotubes, carbon quantum dots, and nanodiamonds, focusing on their synthesis methods, structural variations, and respective applications	U, An	1,2,3
CO-5	Outline the general methods for synthesizing selected metal oxide nanoparticles and their characterization techniques, highlighting their unique physical and chemical properties and applications in areas such as photocatalysis and drug delivery	Ap, An	1,2,3,4,5
CO-6	Apply acquired knowledge to critically analyse and solve problems related to the synthesis, characterization, and application of carbon-based nanomaterials and metal oxide nanoparticles, demonstrating proficiency in evaluating the	E	1,2,3,4

	suitability of these materials for specific technological applications		

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY OF NANOPARTICLES-S IV

Credits: 3:0:1 (Lecture:Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	C	L	
2	CO-2	1,3,5	Ap	P	T	
3	CO-3	1,2,3	An, E	C	L	
4	CO-4	1,2,3	U, An	C	L	
5	CO-5	1,2,34,5	Ap, An	P		P
6	CO-6	1,2,3,4	E	M		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	2	-	-	2S	1	-	-	-	-	-	-
CO 2	2	-	3	-	2	1	2	-	-	-	-	2	-
CO 3	2	2	2	-	-	2	2	-	-	-	-	2	-
CO 4	3	2	3	-	-	2	1	-	-	-	-	2	-
CO 5	2	3	3	1	3	3	3	-	-	-	-	1	-
CO 6	2	2	2	2	-	2	3	-	-	-	-	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓		✓
CO 5	✓			
CO 6	✓			

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE314**				
Course Title	**PHARMACEUTICAL AND MEDICINAL CHEMISTRY-III**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Knowledge on different stereoisomers of compounds 2. UK3DSECHE207, UK4DSECHE207				
Course Summary	Explore the role of public health interventions in disease prevention and control, including surveillance systems, outbreak investigations, contact tracing, quarantine measures, and health promotion initiatives targeting at-risk populations.				

Detailed Syllabus:

Module	Unit	Content PHARMACEUTICAL AND MEDICINAL CHEMISTRY-III	Hrs 60
I	**CAUSE AND PREVENTION OF DISEASES**		**9**
	1.1	Causes, prevention and treatment: Insect borne diseases– malaria, filariasis, diphtheria, whooping cough, influenza, measles, plague	2
	1.2	Air borne diseases: mumps, common cold, tuberculosis	3
	1.3	Water borne diseases: cholera, typhoid, dysentery	3
	1.4	Digestive system – jaundice; Respiratory system – asthma;	1
II	**ANALGESICS, ANTIPYRETIC AGENTS AND ANTI-CANCER DRUGS**		**18**
	2.1	Classification – opioid, on-opioid-Mechanism of action of narcotic analgesics and its pharmacophore requirement-Morphine and its phenolic hydroxyl derivative (SAR of Morphine), Alcoholic hydroxy substituted derivatives and its effects -clinical use and side effect of narcotics	3
	2.2	Introduction to Antipyretics and Analgesics -Salicylic acid and P-Aminophenol derivative (synthesis of Aspirin, Sulphasalazin and Paracetamol)	2
	2.3	Comparison of SAR of Phenacetin and Paracetamol	2
	2.4	Synthesis and SAR of Oxicams	2

	2.5	Introduction to antineoplastic agents -Classification of cancer based on tissue and type of cells	1
	2.6	Non-specificity of cancer drug -classification of Anti-neoplastic agents- a) Alkylating agents-Mechlorethamine, Cyclophosphamide (Synthesis and Mechanism of action)	2
	2.7	b) anti metabolites – methotrexate, fluouracil (synthesis and specify the type of cancer it is used)	2
	2.8	c) Plant product: Vinca alkaloids – vincristine and vinblastine (targeted cancer); Taxol Derivative-Paclitaxel, Docetaxel (source and use with elementary knowledge on activity)	2
	2.9	d) Antibiotics-Daunorubicin and Doxorubicin (structure and Use)	2
III	**GENERAL TOPICS IN PHARMACEUTICALS**		**9**
	3.1	Types – management of diabetes – insulin and its action-Biguanides - Phenphormin, Metformin – Buformin	1
	3.2	Cardiovascular drugs– cardiac glycosides	1
	3.3	Utility of antiarrhythmic agents – quinidine, propranolol hydrochloride	1
	3.4	Utility of anti- hypertensive drugs - Aldomet, pentolinium tartarate vasodilator- tolazoline hydrochloride, sodium nitroprusside.	4
	3.5	Anti-HIV and Covid Drugs-Causes, symptoms and prevention -HIV drugs-AZT, DDC- Covid Vaccination	2
IV	**ANTIPSYCHOTICS DRUGS AND CORRELATION OF PHYSICOCHEMICAL PROPERTIES WITH BIOACTIVITY**		**9**
	1	Antipsychotics Drug: SAR of Phenothiazeines (alkylside chain and phenothiazine ring)- Promazine hydrochloride, Chlorpromazine hydrochloride*, Ring Analogues of Phenothiazeines: Chlorprothixene, Thiothixene, Loxapine succinate, Clozapine	3
	2	Significance of Ionization, Solubility and Partition Coefficient of drugs and biological activity. Elementary knowledge on Isosters, Bioisosterism with examples, Influence of weak bond (1-7 kcal/mol) and strong bonds in Biomolecules and its Thermodynamics (Hydrogen bonding, van der Waals force, ionic bond, covalent bond, Hydrophobic interaction) -delta G of Pyrophosphate, Nucleoside di and triphosphate, Thioesters - Binding interactions in Proteins and Drug.	4
	3	Stereochemistry of drug and its specificity (examples -Thalidomide, Lactic acid, Cisplatin)	2
V	**OPEN ENDED MODULE: Learning through Discussion, Assignment, Presentation, Quizzes, Open book exams etc**		12
	1.	Provide case studies of outbreaks related to insect-borne diseases and air born disease of recent times. Have students analyze the factors contributing to the outbreak, identify preventive measures that could have been implemented, and propose strategies for containment	
	2	Ask students to identify common factors contributing to the spread of these diseases, such as sanitation issues or contaminated water sources. Then, discuss strategies for improving water quality and sanitation	

	3	Debates: Divide students into groups and assign each group a controversial topic related to the clinical use of narcotics, such as the legalization of medical marijuana or the prescription of opioids for chronic pain	
	4	Current Events Discussion: Engage students in a discussion about the causes, symptoms, and prevention strategies for HIV/AIDS and Covid-19. Encourage them to explore recent developments in HIV/AIDS treatment,	
	5	Conduct test to check previous knowledge about the physical parameters like Ionization, Solubility and Partition Coefficient	

References

1. James B. Watson, *Molecular Biology of the Gene*, Pearson, 7th edition
2. D Sriram and Yogeeswari, *Medicinal chemistry* 2nd edition
3. Chatwal G R, (2013), *Pharmaceutical chemistry, inorganic (vol-I*) 6th ed, Himalaya publishing house, Bombay.
4. Chatwal G R, (1991), *Pharmaceutical chemistry, organic (vol-II)*., Himalaya publishing house, Bombay.
5. Patrick G, (2002), *Instant Notes Medicinal Chemistry*, Viva Books Private Limited, New Delhi.
6. Ashutosh Kar, (2018), *Medicinal chemistry*, 7th ed., Publishers, New Delhi.
7. Jayashree Ghosh, (1999), *A text book of pharmaceutical chemistry*, 2nd ed., S.Chand& company, New Delhi.
8. Lakshmi S, (2004), *Pharmaceutical chemistry*, 3rd ed., Sultan chand& sons, Delhi.
9. *Medical Pharmacology* by KL Tripathi
10. *Medical pharmacology Padmaja Udayakumar*, CBS Publishers and Distribution Pvt Ltd

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students will demonstrate an understanding of the modes of transmission of insect-borne, air-borne, and water-borne diseases, including the role of vectors, pathogens, environmental factors, and human behavior in disease spread	U	PSO3
CO-2	Students will analyze the pharmacokinetic properties of analgesic drugs, including absorption, distribution, metabolism, and excretion, and their implications for drug efficacy, safety, and dosing regimens.	R, U	PSO1
CO-3	Students will critically evaluate the risk-benefit	An, E	PSO1,5

	profile of cytotoxic agents in cancer treatment, considering factors such as efficacy, toxicity, patient tolerance, treatment goals, and quality of life outcomes		
CO-4	Students will be familiarized with oral anti-diabetic agents used in the management of diabetes their mechanisms of action, therapeutic indications, and adverse effects.	U	PSO3
CO-5	Students will be familiar with evidence-based strategies for preventing COVID-19 transmission, including vaccination, non-pharmaceutical interventions. Students will acquire knowledge of effective HIV prevention strategies.	U, An	PSO-2
CO6	These interactive activities not only deepen students' understanding of disease biology but also promote critical thinking and collaboration skills essential for addressing public health challenges	R, E	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHARMACEUTICAL AND MEDICINAL CHEMISTRY-III

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO3	U	F	L	-
2	CO-2	PSO1	R, U	C, P	L/T	-
3	CO-3	PSO1,5	An, E	F, C	L/T	-
4	CO- 4	PSO3	U	C, P	L	-
5	CO- 5	PSO-2	U, An	C, P	L/T	-
6	CO6	PSO-1,2,3	R, E	p	-	p

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	-	-	1	-	-	-	-	-	-	1	-	-	-
CO 2	2	-	-	-	-	-	2	-	-	-	-	-	-
CO 3	1	-	-	-	2	3	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	3	-	-
CO 5	-	2	-	-	-	-	-	-	-	1	-	-	-
CO 6	1	2	2	-	-	1	-	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5DSECHE315**				
Course Title	**PHARMACEUTICAL AND MEDICINAL CHEMISTRY-IV**				
Type of Course	**DSE**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Basic knowledge on units of concentration and inorganic analysis of cations and anions 2. UK3DSECHE207, UK4DSECHE207, UK5DSECHE314				
Course Summary	This course provides a comprehensive understanding of pharmaceutical analysis, impurity detection, inorganic pharmaceuticals, biomaterials, and drugs acting on the nervous system, preparing students for careers in pharmaceutical research, development, and quality assurance.				

Detailed Syllabus:

Module	Unit	Content PHARMACEUTICAL AND MEDICINAL CHEMISTRY-IV	Hrs 75
I	**IMPURITIES IN PHARMACEUTICALS:**		**9**
	1.1	Scope and objectives Sources and types of errors: Accuracy, precision, significant figures-Determinate error and indeterminate error(examples)-Steps to minimize systemic errors	3
	1.2	Source and effect of impurities in Pharmacopoeial substances-raw materials, reagents, intermediate atmospheric contaminants, adulterants, side products	3
	1.3	Importance of limit test, Principle and procedures of Limit tests for chlorides, sulphates, iron, heavy metals and arsenic.	3
II	**INORGANIC PHARMACEUTICALS:**		**9**
	2.1	Haematinics: Ferrous sulphate, Ferrous fumarate, Ferric ammonium citrate, Ferrous ascorbate, Carbonyl iron	3
	2.2	Gastro-intestinal Agents: Antacids: Aluminium hydroxide gel, Magnesium hydroxide, Sodium bicarbonate, Calcium Carbonate, Acidifying agents, Adsorbents, Protectives, Cathartics	3
	2.3	Topical agents: Silver Nitrate, Ionic Silver, Chlorhexidine Gluconate, Hydrogen peroxide, Boric acid, Bleaching powder, Potassium permanganate	3

III	**BIOMETERIALS IN IMPLANTS**		**9**
	3.1	Physical and chemical property of materials that get utilized in -Dental Implant - Stent(Co-Cr alloy, Stainless steel)	3
	3.2	Orthopaedic implant (metals, ceramics and polymers)	2
	3.3	Physical and chemical property that utilizes Ir-Si-Pt based metals in Cochlear implants (examples of other metals currently used)	2
	3.4	Biocompatible materials-polytetrafluoroethylene implants, PMMA (use, limitations, preparation and physical properties)	1
	3.5	Application and Advantages of Titanium and Titanium based Alloys	1
IV	**DRUGS ACTING ON PERIPHERAL AND CENTRAL NERVOUS SYSTEM-I**		**18**
	4.1	Use and structure of following drug Anesthetics: Thiopental Sodium*, Ketamine Hydrochloride*, Propofol	3
	4.2	Sedatives and Hypnotics: Diazepam*, Alprazolam*, Nitrazepam, Phenobarbital*	3
	4.3	Anticonvulsants: Phenytoin*, Carbamazepine*, Clonazepam, Valproic Acid*, Gabapentin*,	4
	4.4	Anti-Depressants: Amitriptyline Hydrochloride*, Imipramine Hydrochloride*, Fluoxetine*	4
	4.5	Venlafaxine, Duloxetine, Sertraline, Citalopram, Escitalopram, Fluvoxamine, Paroxetine	4
V	**PRACTICALS II- PHARMACEUTICAL & MEDICINAL CHEMISTRY**		**30**
	1	1. Preparation of inorganic pharmaceuticals a. Boric acid b. Potash alum c. Ferrous sulphate	
	2	2. Test for purity: a. Swelling power of Bentonite b. Neutralizing capacity of aluminum hydroxide gel	
	3	3. Qualitative analysis of carbohydrates a. Glucose b. Fructose c. Lactose d. Sucrose e. Starch	
	4	4. Identification tests for Proteins: albumin and Casein	

Reference:

1. *Pharmaceutical Chemical Analysis: Methods for Identification and Limit Test*: Ole Pederson, CRC Press 2006,
2. Harikishan Singh and VK Kapoor *Medicinal & Pharmaceutical chemistry*
3. K.L Tripathi, *Essentials of Medical Pharmacology*.

4. Carl E. Mesh *Contemporary Implant Dentistry*
5. Wilson and Griswold's *Text book of Organic Medicinal and pharmaceutical Chemistry*

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding the principles and techniques used in pharmaceutical analysis. Importance of accurate and precise measurements in drug formulation and quality control	U	PSO-1,2,3
CO-2	Identifying determinate and indeterminate errors with examples	R, U	PSO-1,3
CO-3	Studying haematinics like ferrous sulphate, ferrous fumarate, etc., used in treating iron deficiency. Exploring gastrointestinal agents such as antacids and their mechanisms of action.	U	PSO-1,3
CO-4	Understanding the properties and applications of topical agents like silver nitrate and chlorhexidine gluconate.	Ap	PSO-1,3,4
CO-5	Differentiate anaesthetics, sedatives, hypnotics, anticonvulsants, and antidepressants.	An	PSO-1,3,5
CO6	Develop practical skill in preparing various pharmaceutical agents like Boric acid, Potash alum. Ferrous sulphate.	Ap	PSO-1,2,3,4,5

S-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHARMACEUTICAL AND MEDICINAL CHEMISTRY-IV

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,2,3	U	F	L	-
2	CO-2	PSO-1,3	R, U	C, P	L/T	-
3	CO-3	PSO-1,3	U	F, C	L/T	-
4	CO- 4	PSO-1,3,4	Ap	C, P	L	-

5	CO- 5	PSO-1,3,5	An	C, P	L/T	-
6	CO6	PSO-1,2,3,4,5	Ap	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	3	2	-	-	2	-	-	-	-	-	-	-
CO 2	2	-	1	-	-	1	-	-	-	-	-	-	-
CO 3	1	-	2	-	-	-	-	-	3	-	-	-	-
CO 4	1	-	3	4	-	2	-	-	1	-	-	-	-
CO 5	1	-	2	-	2	-	-	2	-	-		-	-
CO 6	1	2	2	1	2	-	-	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5SECCHE300**				
Course Title	**ANALYTICAL SKILLS**				
Type of Course	**SEC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3
Pre-requisites	1.Basic knowledge, interest and lab skills in chemistry				
Course Summary	The course covers different concentration terms, various parameters of water, water quality analysis, components of soil ad its analysis, detection of carbohydrate, estimation of sugar, common food adulterants and its detection.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		ANALYTICAL SKILLS	**45**
I	**INTRODUCTION TO CONCENTRATION TERMS**		**6**
	1	Molality, molarity, normality,	2
	2	Mole fraction, mass percentage, ppm, ppb	2
	3	Simple numerical problems.	2
II	**WATER ANALYSIS**		**9**
	4	Composition- Hardness testing- Chromatographic analysis- pH – Salinity testing- Ionic composition – Minerals- Pollutants – DO, BOD, COD, EC, DTC	3
	5	Nutrient Parameters – Portability of Water, Heavy Metal Testing, Types of Heavy metals- Toxicity testing- Biological methods - Chemical Methods	3
	6	Microscopical methods- AAS- Spectrophotometer- CPES-Flame Photometer- Hydrocarbon testing (PAH).	3
III	**SOIL ANALYSIS**		**9**
	7	Definition of Soil, Soil Components: Air, Water, inorganic and organic solids. Formation of Soil, Physical Properties	3
	8	Types of Soils & Basic Concepts Properties of Soil (, Chemical Properties and Biological Properties), Fertility of Soils, soil deficiency with respect to macro and micronutrient components,	3

	9	Brief study of micronutrient & macronutrient, sources & Importance, Remedial measures to overcome deficiencies. Determination of pH of soil (Hands on training).	3
IV	**SUGAR & FOOD ANALYSIS**		**12**
	10	Introduction to carbohydrate, classification, Method for glucose estimation - Enzymatic method, Chemical method	2
	11	Estimation of glucose in urine sample, Estimation of glucose in CSF sample, Normal values, GTT	2
	12	Principle of carbohydrate chemistry – Benedict test, Molisches test, Iodine test (Hands on training).	2
	13	Introduction Food additives, Preservatives, antioxidants, artificial sweeteners, flavors, flavor enhancers, stabilizers.	2
	14	General Analytical methods for milk, milk constituents and milk products like ice cream, milk powder, butter, margarine, cheese including adulterants (Hands on training)	4
V	**OPEN ENDED MODULE**		**9**
	15	Seminar presentations, group discussions, debates, quizzes, case studies, hands on training etc on the above modules -search for different concentration terms in scientific literature, product labels or everyday life to describe the amount of solute in a solution -concentration of a given solute in solution using different concentration terms – collection of water samples from different sources and analysing them for various parameters such as pH, dissolved oxygen, turbidity, conductivity, and specific ions – Analyse and compare with standard soil samples from different locations – discussions on current issues and controversies related to sugar and food analysis, sugar substitutes, food labelling regulations and public health initiatives etc. **(Or any other related activities introduced by the teacher)**	9

REFERENCES

1. De., *Environmental Chemistry*, 6th Edition, New Age International
2. *Environmental studies*; Dr. K. Mukkanti, S. Chand &Camp Ltd
3. B.A. Yagodin (Ed). *Agricultural Chemistry*, 2 Volumes, Mir Publishers (Moscow), 1976.
4. Swaminathan M. *Text Book on Food chemistry, Printing and Publishing CO., Ltd., Bangalore.* 1993.
5. Norman N. Potter, *Food science, CBS publishers and distributors, New Delhi.* 1994.
6. Ramakrishnan S., Prasannam K.G and Rajan R –*Principles. Text book of medical biochemistry. Orient Longman* Ltd. III ed. 2001.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Develop skills in preparing different concentration of solutions	Ap	PSO-1,2,3,4
CO-2	Analyse different components present in water	An	PSO-1,2,3,4
CO-3	Develop skills on analysing different types of soil	An	PSO-1,2,3,4
CO- 4	Analyse different types of carbohydrate	An	PSO-1,2,3,4
CO- 5	Develop an idea about different food adulterants and skills in handling it.	An	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL SKILLS

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3,4	Ap	F	L	-
2	CO-2	PO-1,2,3,8 PSO-1,2,3,4	An	C, P	L/T	-
3	CO-3	PO-1,6 PSO-1,2,3,4	An	F, C	L/T	-
4	CO- 4	PO-1,2,3,8 PSO-1,2,3,4	An	C, P	L	-
5	CO- 5	PO-1,6,8 PSO-1,2,3,4	An	C, P	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	3	2	-	1	-	-	-	-	3	-	-
CO 2	2	3	3	2	-	2	1	1	-	-	-	-	2
CO 3	2	3	3	2	-	1	-	-	-	-	3	-	-
CO 4	2	3	3	2	-	2	1	1	-	-	-	-	2
CO 5	2	3	3	2	-	1	-	-	-	-	3	-	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5		✓	✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK5SECCHE301**				
Course Title	**PREPARATION AND FORMULATION OF HERBAL PRODUCTS**				
Type of Course	**SEC**				
Semester	5				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3
Pre-requisites	1. Basic knowledge, interest and lab skills in chemistry				
Course Summary	The course covers different types of herbal formulations, herbal products, analytical techniques in herbal products, different medicines extracted from herbs, identification and separation of phytochemicals from herbs.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		PREPARATION AND FORMULATION OF HERBAL PRODUCTS	**45**
I	**INTRODUCTION TO HERBS AND HERBAL PRODUCTS**		**6**
	1	Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation	2
	2	Source of Herbs, Selection, identification and authentication of herbal materials	2
	3	Processing of herbal raw material.	2
II	**FORMULATION OF HERBAL PRODUCTS & ANALYTICAL TECHNIQUES**		**15**
	4	Conventional herbal formulations like syrups, mixtures and tablets	3
	5	Novel dosage forms like phytosomes, preservation and Advantages.	4
	6	Introduction, drug adulteration, drug evaluation and analytical evaluation	4
	7	Chromatography and chemical fingerprints of herbal medicine.	4
III	**MEDICINAL HERBS**		**6**
	8	Anti parasitical, anthelminthic, antibacterial and antiviral herbs	3
	9	Diuretic, digestic, expectorant and demulcent herbs.	3
IV	**IDENTIFICATION OF PHYTOCHEMICALS**		**9**
	10	dentification of phytochemicals in commonly available plants, eg. Basil, Neem	4
	11	Separation of phytochemicals from any one plant (Hands on Training).	5
V	**OPEN ENDED MODULE:**		**9**

	12	Seminar presentations, group discussions, debates, quizzes etc on the above modules – written reports/presentations/multimedia projects on specific medicinal herb, its botanical characteristics, phytochemical composition, pharmacological properties, therapeutic uses, safety considerations etc, cultural and historical significance of herbs and herbal products in different regions and societies, workshop on analytical techniques commonly used in the quality control and standardization of herbal products, hands on training on sample preparation, instrument operation, data analysis and interpretation, literature review on a specific medicinal herb and scientific evidence supporting its health benefits etc **(Or any other related activities introduced by the teacher)**	9

REFERENCES

1. Neelesh Malviya, and Sapna Malviya, *Handbook of Herbal Formulations 2021,* Eurospan Publisher Imprint: CBS Publishers & Distributors Pvt Ltd, India.
2. Vimaladevi M, *Textbook of Herbal Cosmetics*, CBS Publishers & Distributors.
3. Sahu, *Herbal Drug Formulation and Standardization* Ane Books Pvt Ltd
4. Magazine R, *Herbal Food and Pharmaceutical Products*, CBS PUBLICATION.
5. Venkateshwara Rao, Leticia Rao, *Phytochemicals: Isolation, Characterisation and Role in Human Health*.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss different types of herbs and herbal products	U	PSO-1,2
CO-2	Discuss different analytical techniques in herbal products	U	PSO-1,2
CO-3	Develop skills in producing different herbal medicines	Ap	PSO-1,2,3
CO-4	Identify different types of herbal formulations	U	PSO-1,2
CO-5	Develop skills on identification and separation of phytochemicals	An	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PREPARATION AND FORMULATION OF HERBAL PRODUCTS

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,3,6 PSO-1,2	U	F	L	-
2	CO-2	PO-1,3,6,7 PSO-1,2	U	C	L	-
3	CO- 3	PO-1,3,6 PSO-1,2,3	Ap	P	L	-
4	CO-4	PO-1,3,6,7 PSO-1,2	U	C	L	-
5	CO-5	PO-1,3,6,7 PSO-1,2,3,4	An	P, M	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	-	-	-	2	-	2	-	-	2	-	-
CO 2	2	3	-	-	-	2	-	2	-	-	2	1	-
CO 3	2	3	2	-	-	2	-	2	-	-	2	-	-
CO 4	2	3	-	-	-	2	-	2	-	-	2	1	-
CO 5	2	3	2	1	-	2	-	2	-	-	2	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5		✓	✓	

SEMESTER 6

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSCCHE300**				
Course Title	**PHYSICAL CHEMISTRY III**				
Type of Course	**DSC**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. A solid understanding of general chemistry concepts. 2. Familiarity with mathematical techniques such as calculus and differential equations				
Course Summary	This physical chemistry course aims to familiarize students with important fundamental areas such as electrolytic conductance, electromotive force and thermodynamics. Additionally, it covers topics such as adsorption phenomena, binary liquid systems, and practical applications in physical chemistry experiments, providing students with a comprehensive understanding of the discipline's theoretical and practical aspects.				

Detailed Syllabus:

Module	Unit	Content PHYSICAL CHEMISTRY III	Hrs 75
I	**ELECTROLYTIC CONDUCTANCE**		**9**
	1	Equivalent Conductance, Molar conductance and its variation with dilution, transport number, Kohlraush's law and its applications.	2
	2	Applications of conductivity measurements - Determination of degree of dissociation of weak electrolytes, degree of hydrolysis, solubility of sparingly soluble salts, conductometric titrations involving strong acid strong base, strong acid-weak base, weak acid- strong base, weak acid-weak base and precipitation.	3
	3	Debye-Huckel theory of strong electrolytes, Debye-Huckel-Onsager equation (elementary idea), Debye-Falkenhagen effect, Wien effect.	2
	4	Activity and activity coefficient of electrolytes, Ionic strength.	2
II	**ELECTROMOTIVE FORCE**		**9**
	5	Origin of electrode potential, half-cell reaction and cell reactions, Types of electrodes-Metallic electrodes, anion reversible electrodes and redox	3

		electrodes. Reference electrodes: standard hydrogen electrode, calomel electrode.	
	6	Effect of concentration of electrolytes on electrode potential: Nernst equation for electrode and cell (Derivation). Concentration cells, liquid junction potential.	2
	7	Relation between electrical energy, free energy, enthalpy and entropy-Gibb's Helmholtz equation and EMF of a cell - calculation of ΔG, ΔH and ΔS from EMF data.	2
	8	Fuel Cells – H_2-O_2, hydrocarbon-O_2. Applications of EMF measurements-Determination of pH using hydrogen electrode and potentiometric titrations of redox systems with Fe/Cr system.	2
III	**THERMODYNAMICS**		**18**
	9	Definition of internal energy and enthalpy, First law of thermodynamics, mathematical form.	1
	10	Reversible process and maximum work. Calculation of work, heat, internal energy change and enthalpy change for the expansion of an ideal gas under reversible isothermal and adiabatic condition.	2
	11	The Joule-Thomson effect – isenthalpic process, Joule-Thomson coefficient, derivation of the expression for Joule-Thomson coefficient.	1
	12	Thermochemistry – Standard state. Standard enthalpies of reactions: Enthalpies of formation, combustion and neutralization. Hess's law and its applications. Kirchoff's equations.	2
	13	Limitations of First Law, Need for Second law of thermodynamics. Spontaneous process. Carnot cycle:-net work done and efficiency of Carnot engine, Carnot theorem. Different statements of Second law.	3
	14	Concept of entropy- Definition and physical significance. Entropy as a function of volume and temperature, pressure and temperature, as a criterion of spontaneity and equilibrium. Entropy changes in reversible and irreversible processes. Entropy changes accompanying change of phase	2
	15	Free energy: Gibbs and Helmholtz free energies and their significances - criteria of thermodynamic equilibrium and spontaneity. Gibbs-Helmholtz equation, dependence of Gibbs free energy changes on temperature, volume and pressure.	2
	16	Partial molar quantities. Chemical potential-Gibbs-Duhem equation, Clausius Clapeyron equation. Concept of fugacity, determination of fugacity by graphical method.	2
	17	Nernst heat theorem, proof and its consequences. Statement of Third Law-Plank's statement, Lewis Randall statement. Concept of perfect crystal, evaluation of absolute entropies of solid, liquid and gas. Exception to IIIrd law with reference to examples- CO, NO, N_2O and H_2O	3
IV	**BINARY LIQUID SYSTEMS & ADSORPTION**		**9**
	18	Liquid-Liquid system: ideal and non-ideal mixtures, Raoult's law, deviations from Raoult's law, vapour pressure - composition, temperature-composition curves, fractional distillation, Azeotropic mixtures.	2
	19	Partially miscible liquid system, critical solution temperature, examples for upper, lower and upper cum lower CST	2

	20	Distribution law, its thermodynamic derivation, Application of distribution law to the study of association and dissociation of molecules	2
	21	Adsorption: Physical and chemical adsorption, Freundlich adsorption isotherm, Derivation of Langmuir adsorption isotherm, Statement and explanation of BET and Gibbs isotherms	2
	22	Determination of surface area of adsorbents by BET equation. Applications of adsorption	1
V	**PRACTICALS: PHYSICAL CHEMISTRY EXPERIMENTS**		**30**
		A minimum of 8 practical experiments out of which at least one each from sections I, II and III must be performed and reported.	
	23	**A. Conductometry**	5
		21. Determination of cell constant 22. Conductometric titration of NaOH using HCl	
	24	**B. Potentiometry**	6
		23. Potentiometric titration of Fe^{2+} versus $Cr_2O_7^{2-}$ 24. Potentiometric titration of $KMnO_4$ versus KI	
	25	**C. Experiments with Partially miscible liquid pairs**	3
		25. Critical solution temperature of phenol –water system 26. Influence of KCl (impurity) on the miscibility temperature of Phenol-water system. Determination of concentration of given KCl solution	
	26	**D. Adosrption Experiments**	6
		27. Freundlich and Langmuir isotherms for adsorption of oxalic acid on active charcoal. 28. Determination of unknown concentration of oxalic acid using isotherm.	
	27	**E. Calorimetry**	5
		29. Determination of water equivalent of Calorimeter and heat of neutralization of strong acid and strong base	
	28	**F. Partition experiments**	5
		30. Partition coefficient of iodine between CCl_4 and H_2O or Partition coefficient of ammonia between $CHCl_3$ and H_2O	

References:

Textbooks

1. P W Atkins, "*Physical Chemistry*", Oxford University Press
2. R L Madan, *Physical Chemistry*, Mc Graw Hill
3. *Elements of Physical Chemistry*, Glasstone and Lewis, Macmillan
4. Puri, Sharma & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co
5. P. C. Rakhit, *Physical Chemistry*, Sarat Book House, Calcutta
6. J. B. Yadav *Advanced Practical Physical Chemistry*, Krishna Prakashan Media (P) Ltd

For Further Reading

1. R J Selby and RA Alberty, *Physical Chemistry*, John Wiley &sons
2. Levin, *Physical Chemistry*, 5th edn, TMH.
3. Gurdeep Raj, *Advanced Physical Chemistry*, Goel publishing house
4. S Glasstone, *“Thermodynamics for Chemists*”, Affiliated East West Publishers
5. G W Castellan, “*Physical Chemistry*”, Narosa Publishing House
6. S Glasstone, *An Introduction to Electrochemistry*, East-West Press (Pvt.) Ltd.
7. Viswanathan, P. S. Raghavan, *A Practical Physical Chemistry*, Viva Books

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Recall the basic physical concepts in electrochemistry, thermodynamics, adsorption and binary liquid systems	R	PSO-1,2,3
CO-2	Understand the basic concepts involved electrochemistry, thermodynamics, adsorption and binary liquid systems	U	PSO-1,2,3
CO-3	Apply laws of thermodynamics in physical and chemical processes and real system	Ap	PSO-1,2,3
CO-4	Discuss the second law of thermodynamics and assess thermodynamic applications using second law of thermodynamics.	E, Ap	PSO-1,2,3
CO-5	Develop Scientific outlook and approach in applying principles of physical chemistry in chemical systems/reactions	U	PSO-1,2,3,4
CO-6	Acquire Instrumentation skill in using conductometer, potentiometer, calorimeter	U	PSO-1,2,3,4
CO-7	Compare theory with experimental findings	An	PSO-1,2,3
CO-8	Practice Punctuality and regularity in doing experiments and submitting Lab records	Ap	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHYSICAL CHEMISTRY III

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	U	F, C	L	-
3	CO-3	PO-1,2,6 PSO-1,2,3	Ap	M	L	-
4	CO-4	PO-1,6 PSO-1,2,3	E, Ap	M	L	-
5	CO-5	PO-1,2,3,6 PSO-1,2,3,4	U	F, C	L	-
6	CO-6	PO-1,6 PSO-1,2,3,4	U	P	-	P
7	CO-7	PO-1,2,3,6 PSO-1,2,3	An	P	-	P
8	CO-8	PO-6,8 PSO-1,2,3,4,5	Ap	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	1	-	-	-	-	3	-	-
CO 2	3	3	2	-	-	1	-	-	-	-	3	-	-
CO 3	3	3	2	-	-	2	1	-	-	-	3	-	-
CO 4	3	3	2	-	-	1	-	-	-	-	3	-	-
CO 5	2	2	3	3	-	2	1	1	-	-	3	-	-
CO 6	2	2	3	3	-	1	-	-	-	-	2	-	-
CO 7	2	2	3	-	-	1	1	1	-	-	2	-	-
CO 8	1	1	1	2	2	-	-	-	-	-	2	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6			✓	
CO 7			✓	
CO 8			✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSCCHE301**				
Course Title	**ANALYTICAL PRINCIPLES II**				
Type of Course	**DSC**				
Semester	6				
Academic Level	300 -399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. A fundamental understanding on general chemistry 2. UK4DSCCHE201				
Course Summary	The course explores into electrochemistry for analysis, covering topics such as electrode potentials, potentiometric titrations, conductometry, coulometric analysis, and voltametric methods, providing students with a comprehensive understanding of electroanalytical techniques and their applications in analytical chemistry. Additionally, electron microscopy techniques including SEM, TEM, and AFM, as well as non-spectroscopic techniques like radiochemical methods and thermal analysis methods, are explored. Equipping students with practical skills and theoretical knowledge essential for experiments in physical chemistry.				

Detailed Syllabus:

Module	Unit	Content ANALYTICAL PRINCIPLES II	Hrs 75
I	**ELECTROANALYTICAL TECHNIQUES**		**12**
	1	Electrochemical cells and electrode potentials: Voltaic cells, using standard potentials to predict reactions, Anodes, cathodes, and cell voltages, The Nernst equation, Calculating electrode potentials before and after reaction, The formal potential, Limitations of Electrode potential	3
	2	Potentiometric titrations: Potentiometric Electrodes and Potentiometry: Balancing redox reactions, Calculating the reaction equilibrium constant from standard potentials, calculating redox titration curves, Visual Detection of the endpoint: Self indication, Starch, Redox indicators, Redox Titrations - Using Platinum Electrodes, Derivative titrations	3
	3	Conductometry: General considerations, The measurement of conductivity, Conductometry as an analytical tool, Applications of direct conductometric measurements, The basis of conductometric titrations, Types of conductometric titrations, Apparatus and measurements,	3

		Applications of conductometric titrations, High-frequency titrations (oscillometry)	
	4	Coulometric Analysis - Theory, Faraday's laws, Coulometers Introduction to the technique.	1
	5	Voltametric Methods of Analysis: Introduction, Principle, Types of Voltametric Techniques (Introduction of the techniques only): Polarography, Hydrodynamic Voltammetry, Stripping Voltammetry, Amperometry, Applications of Voltametric Method of Analysis	2
II	**ELECTRON MICROSCOPY (AFM, SEM, TEM)**		**12**
	6	Electromagnetic Radiation, Scanning Electron Microscopy (SEM) - principles, Imaging Modes, Energy Dispersive X-ray Spectroscopy (EDAX)- SEM: Applications, Limitations.	3
	7	Transmission Electron Microscopy (TEM) - principles, Imaging Modes, Applications, Limitations.	3
	8	Scanning Probe Microscopy (SPM) - Principles, Applications & Limitations.	1
	9	Scanning Tunnelling Microscope: Principles, Modes of operation, Applications, Limitations	2
	10	Atomic Force Microscopy (AFM) - basic principles, instrumentation, operational modes, Applications, Limitations	3
III	**NON-SPECTROSCOPIC TECHNIQUES**		**12**
	11	Radio chemical methods of analysis: Detection and measurement of radioactivity, Introduction to radioactive tracers, Applications of tracer technique, Isotope dilution analysis - applications, Activation analysis – Application, Advantages and disadvantages, Radiocarbon dating technique	4
	12	X- ray Methods of Analysis: Principle, Theory- X-ray spectral lines, Instrumentation, Powder XRD and Single crystal XRD, Chemical analysis using X-ray absorption, X-ray Diffraction, Chemical analysis with X-ray diffraction	3
	13	Dipole moment, Measurement of dipole moment by temperature method, Dipole moment and molecular structure, Magnetic susceptibility and unpaired electrons, measurement of magnetic susceptibility, Molar refraction and molecular structure, atomic refraction, Optical exaltation, Parachor and atomic equivalent of parachor.	3
	14	Viscosity- Poisuelle’s equation, Determination of viscosity by Ostwald’s viscometer, Refractive index- determination by Abbe refractometer, Surface tension-factors affecting Surface tension and measurement by capillary rise and stalagmometer method	2
IV	**THERMAL ANALYSIS**		**9**
	15	Thermo gravimetric methods of analysis: Instrumentation, thermogram and information from thermogram, Factors affecting thermogram, Applications, TGA for quantitative analysis.	3
	16	Differential Thermal Analysis (DTA): Instrumentation, general principles, differential thermogram, simultaneous TG-DTA, Applications	1
	17	Differential Scanning Calorimetry (DSC): Principle, Instrumentation, and Applications.	2

	18	Thermometric titrations and evolved gas analysis (EGA): Principle, and Application, Thermomechanical Analysis (TMA) and Dynamic Mechanical Analysis (DMA), Applications of TMA.	3
V	**PRACTICALS: PHYSICAL CHEMISTRY EXPEERIMENTS**		**30**
		A minimum of 5 practical experiments out of which at least one each from sections I, II and III/IV/V must be performed and reported. For plots/graphs, suitable softwares may be used and printed hard copies may be presented. Practical records may be in handwritten or computer-printed form.	
	19	**I. Conductometry**	6
		Determination of cell constant	
		Conductometric titration of strong acid Vs strong base	
	20	**II. Potentiometry**	6
		Potentiometric titration of Fe^{2+} *Vs* $Cr_2O_7^{2-}$	
		Potentiometric titration of $KMnO_4$ *Vs* KI	
		Potentiometric titration of HCl *Vs* NaOH using quinhydrone electrode	
	21	**III. Surface tension**	6
		Determination of Surface tension of any three liquids	
		Surface tension of binary mixtures and determination of concentration of an unknown mixture	
	22	**IV. Viscosity**	6
		Determination of viscosity of any three liquids	
		Viscosity of binary mixtures and determination of concentration of an unknown mixture	
	23	**V. Refractive index experiments**	6
		Determination of refractive indices of any three liquids	
		Refractive indices of KCl solutions of different concentrations and determination of concentration of unknown KCl solution	

References

1. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House
2. H. W. Nürnberg, *Electroanalytical Chemistry*, Wiley-Interscience, 1974
3. Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F.A. Jr., *Instrumental Methods of Analysis*, CBS Publishers & Distributors, 7th Edition, 1986.
4. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
5. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.
6. T. Pradeep, NANO: *The Essentials: Understanding Nanoscience and Nanotechnology*, Tata McGraw-Hill Publishing Company Limited, 1st Edition, 2007,
7. J B Yadav, *Advanced Practical Physical Chemistry*, Goel, Publishing House
8. A.Findlay, "*Practical Physical Chemistry*" Creative Media
9. R.C.Das and E.Behara, "*Experimental Physical Chemistry*", Tata Mc Graw Hill.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain competence in the accurate determination of concentrations, the analysis of redox reactions, the characterization of electrochemical systems, and the provision of analytical laboratory equipment using electroanalytical methods.	U, R	PSO-1,2,3
CO-2	Acquire profound understanding of principles, operational modes, applications, and limitations of different microscopy techniques to effectively analyze nanoscale structures and tensions in diverse scientific and industrial fields.	U, An	PSO-1,2,3
CO-3	Gain proficiency in radiochemical methods of analysis to utilize in diverse scientific and industrial contexts.	An, Ap	PSO-1,2,3,4
CO-4	Develop a deep understanding of X-ray methods of analysis to employ X-ray diffraction and absorption techniques for structural characterization and compositional analysis in materials science and chemistry research.	Ap, E	PSO-1,2,3,4,5
CO-5	Expand a comprehensive understanding of thermal analysis principles, instrumentation, and applications, to analyze thermal properties of materials and conduct quantitative analysis in various fields of research and industry.	Ap, E	PSO-1,2,3,4,5
CO-6	Develop practical skills and theoretical understanding, to apply fundamental principles to solve simple problems, leading to research interest in the field of physical chemistry.	Ap, E	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL PRINCIPLES II

Credits: 3:0:1(Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U, R	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	U, An	C	L	-
3	CO-3	PO-1,2,3,6 PSO-1,2,3,4	An, Ap	C	L	-
4	CO-4	PO-1,2,3,6,7 PSO-1,2,3,4,5	Ap, E	F, C	L	-
5	CO-5	PO-1,2,3,6,7 PSO-1,2,3,4,5	Ap, E	C, P	-	P
6	CO-6	PO-12,3,6,7 PSO-1,2,3,4,5	Ap, E	M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	2	-	-	-	-	3	-	-
CO 2	3	3	2	-	-	2	1	-	-	-	3	-	-
CO 3	2	3	2	2	-	1	2	2	-	-	3	-	-
CO 4	2	3	3	2	2	1	2	2	-	-	2	2	-
CO 5	2	3	3	2	2	1	2	2	-	-	2	2	-
CO 6	2	3	3	2	2	1	2	2	-	-	2	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSCCHE302**				
Course Title	**ORGANIC CHEMISTRY- IV**				
Type of Course	**DSC**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. UK2DSCCHE100, UK4DSCCHE202, UK5DSCCHE304				
Course Summary	Organic Spectroscopy covers UV-Visible, IR, and NMR spectroscopy techniques, enabling students to analyze molecular structures and elucidate functional groups. Additionally, Organophotochemistry and Supramolecular Chemistry introduce photochemical reactions and molecular recognition principles, expanding students' understanding of chemical reactivity and intermolecular interactions in the context of sustainable chemistry practices.				

Detailed Syllabus:

Module	Unit	Content	60 Hrs
I	**ORGANIC SPECTROSCOPY 1**		**9**
	1	UV–Visible spectroscopy – Beer-Lambert's law, types of electronic transitions.	3
	2	Bathochromic, hypsochromic shifts, hyperchromic and hypochromic effects	3
	3	UV-Visible spectra of enes, effect of conjugation – solvent effect - Calculation of λmax of dienes and α,β-unsaturated ketones	3
II	**ORGANIC SPECTROSCOPY 2**		**12**
	4	IR spectroscopy – Molecular vibrations, Functional group and finger print region – group frequencies	3
	5	Effect of hydrogen bonding on –OH stretching frequency.	3
	6	Factors influencing carbonyl stretching frequency. Comparison of carbonyl stretching frequency in compounds containing carbonyl group.	3

	7	Interpretation of IR spectra of simple organic molecules such as salicylaldehyde, benzamide, acetophenone, nitro benzoic acid and phenyl acetate.	3
III	**ORGANIC SPECTROSCOPY 3**		**15**
	8	NMR spectroscopy – principle of proton NMR, shielding and deshielding effect.	4
	9	Chemical shift, factors influencing chemical shift spin-spin splitting, coupling constant.	3
	10	Interpretation of PMR spectrum of simple molecules like CHBr2CH2Br, ethylbromide,pure ethanol and impure ethanol (acidic impurities) acetaldehyde and toluene.	2
	11	Introduction to 13C NMR Structural elucidation of simple organic molecules using IR and NMR spectroscopic techniques.	3
	12	Theory of Mass spectrometry – mass spectrum, base peak and molecular ion peak, types of fragmentation, McLafferty rearrangement, isotopic effect.	3
IV	**ORGANO PHOTO CHEMISTRY**		**12**
	13	Introduction – photochemical Vs thermal reactions. Single and Triplet states b, Allowed and forbidden transition. Photosensitization	4
	14	Photochemical reactions of olefins: Photodimerisation Photochemistry of carbonyl compounds: Norrish I (Acetone), Norrish II cleavages.	4
	15	Introduction to pericyclic reactions: electrocyclic, cycloaddition – [4+2] only Diels Alder reaction, sigmatropic reactions and chelotropic reactions conceptual understanding with definition and examples.	4
V	**SUPRAMOLECULAR AND GREEN CHEMISTRY (Open ended module- This portion can be substituted by any other topics as selected by the teacher and can be evaluated by any method of teacher's choice)**		**12**
	16	Introducing Supramolecular chemistry- molecular recognition– host-guest interactions – types of non-covalent interactions.	4
	17	Green Chemistry: Introduction – atom economy – principles of green chemistry.	4
	18	Newer methods of synthesis: Ultrasound, microwaves and phase transfer catalysis	4

References

Text books

1. A.Bahl and B.S.Bahl, *Advanced Organic Chemistry*, S.Chand& Company, New Delhi.
2. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, *A textbook of Organic Chemistry*, Vikas Publishing House (Pvt) Ltd., New Delhi..

3. S.C.Sharma and M.K.Jain, *Modern Organic Chemistry*, Vishal Publishing Company,New Delhi..
4. I L Finar, "*Organic Chemistry*" Vol – 1&2, 5th Edition, Pearson Education, New Delhi.
5. Gowariker V.R., Viswanathan N.V. and Jayader Sreedhar, *Polymer Science*,Wiley Eastern Ltd, New Delhi.
6. O.P.Agarwal, *Chemistry of Natural Products*, Goel Publications.
7. T.L.Gilchrist, *Heterocyclic Chemistry*, Pearson Education, New Delhi.
8. Y.R.Sharma, *Elementary Organic Spectroscopy*, Pearson Education, New Delhi.
9. William Kemp, *Organic Spectroscopy*, Macmillan, New York.
10. AshuthoshKar, *Medicinal Chemistry*, New Age International Publishers.
11. Helena Dodzuik, *Introduction to supramolecular chemistry*, Springer.
12. V.K.Ahluwalia, *Green Chemistry*, Environmentally Benign reaction, Ane Book.

For Further Reading:

1. R.T.Morrison, R.N.Boyd. *Organic Chemistry*, Pearson Education, New Delhi.
2. P.Y.Bruice, *Essential Organic Chemisty*, Pearson Education, New Delhi.
3. J.Clayden, N.Greeves and S.Warren, *Organic Chemistry*, Oxford University Press, New York.
4. Billmeyer F.W., *Text book of Polymer Science*, John Wiley and Sons.
5. S.P.Bhutani, *Chemistry of Biomolecules*, Ane Book Pvt Ltd.
6. R.M.Silverstein and F.X.Webster, *Spectrometric Identification of Organic Compounds*, John Wiely and Sons, New York.
7. P.S.Kalsi, *Application of Spectroscopic Techniques in Organic Chemistry*, NewAge International, New Delhi.
8. L.M. Lehn, *Supramolecular Chemistry*, VCH.
9. M.M.Sreevastava and Rashmi Sanghi, *Green Chemistry for environment*, Narosa Publishing House.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the principle of UV, IR, NMR and Mass spectroscopic techniques	U	PSO-1,2,3
CO-2	Interpret spectral data to elucidate the structure of simple organic compounds.	R, U, Ap, C	PSO-1,2,3
CO-3	Diffferentiate thermal and photochemical reactions.	U,An	PSO-1,2
CO-4	Discuss the theory of photochemical and pericyclic reactions.	Ap, An	PSO-1,2

CO-5	Understand the fundamentals of supramolecular and green chemical methods.	Ap, An	PSO-1,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ORGANIC CHEMISTRY IV

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,4.5	U	F	L	-
2	CO-2	PSO-1,2,3	R, U, Ap, C	F	L	-
3	CO-3	PSO-1,2,5	U,An	C	L	-
4	CO-4	PSO-1,2	Ap, An	F,C	L	-
5	CO-5	PSO-1,2,3,4,5	U, Ap, C	P	L,T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	2	3	2	-	-	-	-	-	-	-
CO 2	2	3	3	-	-	2	2	-	-	-	-	-	-
CO 3	2	1	-	-	1	2	2	-	-	-	-	-	-
CO 4	2-	2	-	-	-	2	2	-	-	-	-	-	-
CO 5	2	2	3	3	3	2	2	3	-	-	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5	✓	✓	✓	-

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSCCHE303**				
Course Title	**THEORETICAL CHEMISTRY II**				
Type of Course	**DSC**				
Semester	6				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Basic idea about properties of matrices, matrix representation of operations and character value of matrix and its importance. 2. Knowledge about the regions of electromagnetic spectrum, interaction between electromagnetic radiation and matter, origin of molecular and atomic spectra.				
Course Summary	Identification of various symmetry elements associated with the molecule is obtained from group theory. By knowing the symmetry elements, one can assess the point group of the molecule and also can construct group multiplication table. The course introduces the basic principles of group theory and spectroscopy. A detailed discussion about rotational, vibrational, Raman, Electronic, NMR and Mossbauer spectra and their applications are included in various modules.				

Detailed Syllabus:

Module	**Unit**	**Content** **THEORETICAL CHEMISTRY II**	**Hrs** **60**
I	**PRELIMINARIES OF GROUP THEORY**		**6**
	1	Mathematical groups – Conditions for sets of elements to form mathematical groups – closure rule, associativity, existence of identity and inverse elements.	6
	2	Order of a group, Definitions of finite, infinite, Abelian and cyclic groups.	
	3	Block factored matrices, Character of a matrix.	
	4	Combination of elements of a group - the group multiplication table and its features - general group multiplication tables of groups up to order 4.	
	5	Classification of elements in a group, similarity transformation and classes.	

II	**GROUP THEORY FOR THE SYSTEMATIC STUDY OF MOLECULAR SYMMETRY**		**12**
	6	Symmetry elements and symmetry operation-Proper and improper axis of symmetry, plane of symmetry, centre of symmetry and identity element.	2
	7	Symmetry operations. Mathematical combinations of symmetry operations - the point groups, nomenclature of point groups - Schoenflies notations. Determination of point groups of simple molecules - Acetylene, H_2O, NH_3, BF_3, $[Ni(CN)_4]^{2-}$ and C_6H_6.	3
	8	Order of a group. Combination of symmetry operations. Group theoretical rules - the group multiplication tables of C_3, C_{2v}, C_{3v} and C_{2h} point groups.	3
	9	Identifying classes of symmetry operations in point groups (C_3, C_{2v}, C_{3v} and C_{2h})	2
	10	Matrix representation of symmetry operations. Matrices for the symmetry operations of C_3, C_{2v}, C_{3v} and C_{2h} point groups.	2
III	**MOLECULAR SPECTROSCOPY I**		**18**
	11	Regions of electromagnetic spectrum. Wavelength, frequency, wave number. Interaction of electromagnetic radiation with matter. Quantization of energy- photon, various types of molecular excitation and types of molecular spectra.	2
	12	Energy levels in molecules – Born-Oppenheimer approximation. Width and intensity of spectral lines - Doppler broadening-Boltzmann population and transition probability.	2
	13	**Rotational spectroscopy**: Interaction between molecules and microwaves and criteria for microwave activity, rotation of molecules: Types of molecules according to moments of inertia- linear, symmetric top, asymmetric top and spherical top with two examples each. Microwave spectroscopy of rigid diatomic molecules, derivation for $I = \mu r^2$. energy expression, rotational constant, rotational energy levels, selection rule, pure rotational spectra. Separation between spectral lines, equation of J for maximum intensity (no derivation), Determination of bond length. Effect of isotopic substitution on rotational spectra of molecules. Applications of Microwave spectroscopy.	4
	14	**Vibrational spectroscopy**: Types of vibrations in molecules. Criteria for IR activity, Simple Harmonic oscillator model; Hook's law, energy and frequency equations. IR spectra of diatomic molecules. Energy expression, Selection rules, Zero-point Energy, frequency of separation, calculation of force constant. Anharmonic oscillators, Morse equation. Morse potential energy curve for an anharmonic diatomic molecule. Energy expression and Selection rules, Fundamental and overtone transitions. Fermi resonance- Combination and difference bands. Hot bands. Degree of freedom of polyatomic linear and nonlinear molecules. Normal modes	6

		of vibration- Modes of vibrations of CO_2 and H_2O. Skeletal and Group frequency concept– Fingerprint region.	
	15	**Raman spectroscopy**: Rayleigh and Raman Scattering, Interaction between molecules and radiations and criteria for Raman activity, Stoke's and antistoke's lines and their intensity difference. Raman shift. Quantum theory of Raman effect. Induced dipole moment and polarizability, importance of polarizability of molecules in Raman activity. Pure Rotational Raman spectra. Selection rule. Frequency of separation, vibrational Raman spectra, Selection rule, Rule of Mutual exclusion principle (example; CO_2). Complementarity of IR and Raman spectroscopy.	4
IV	**MOLECULAR SPECTROSCOPY II**		**12**
	16	**Electronic spectroscopy of molecules**: Frank-Condon principle-Diagram, Vibrational Coarse Structure. Electronic transitions in diatomic molecules. Electronic spectra of polyatomic molecules (qualitative idea only), Different types of electronic excitations. Effect of conjugation on λ_{max} value. Chromophore and auxochrome – Bathochromic and hypsochromic shifts, hyperchromic and hypochromic shifts.	2 2
	17	Dissociation spectra, continuum and dissociation energy, Determination of Dissociation energy of molecules, Predissociation.	2
	18	Charge transfer spectra - LMCT and MLCT, explanation using simple examples.	2
	19	**Mossbauer Spectroscopy**: Principle, recoil energy and Doppler effect. Isomer shift, Qudrupole splitting and hyperfine interaction with special reference to Fe^{57}, and Sn^{119} compounds.	4
V	**MOLECULAR SPECTROSCOPY III**		**12**
	20	**Proton NMR spectroscopy**: Principle of NMR, nuclear spin. HNMR, Interaction of nuclear spin with external magnet. Energy level splitting, Precession.	2
	21	Chemical shift. Nuclear shielding and deshielding, Delta and tau scales. Factors influencing chemical shift. Presentation of NMR spectra, Low resolution spectra and high resolution spectra- Spin-spin coupling- origin of coupling - coupling constants - NMR spectra of simple molecules.	4
	22	**Carbon-13 NMR Spectroscopy:** C-13 relative abundance, chemical shift, spin-spin coupling. Proton coupled and decoupled C-13 NMR.	2
	23	**Electron spin resonance spectroscopy**: Principle, Types of substances with unpaired electrons, interaction of electron magnet with external magnet. Energy level spliting. Lande splitting factor, presentation of ESR spectrum, the normal and derivative spectra. Hyperfine splitting. Simple examples of methyl and benzene radicals.	4

Books and References:

1. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn., John Wiley & Sons, New York, 1990.
2. Salahuddin Kunju & G. Krishnan, Group Theory & its Applications in Chemistry, PHI Learning Pvt. Ltd.2010.
3. L. Carter Robert, Molecular Symmetry and Group Theory, John Wiley & Sons, 2009.
4. K. Veera Reddy, Symmetry and Spectroscopy of molecules, New Age International, 2005.
5. C. N. Banwell, *Fundamentals of molecular spectroscopy*, McGraw-Hill, 1994.
6. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press 2006.
7. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46. Edn., Vishal Publishing Company, New Delhi, 2013.
8. P. S. Sindhu, Fundamentals of Molecular Spectroscopy, New Age International, 2006.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	*understand* the principles of constructing mathematical groups.	U	PSO-1,2
CO-2	*realise* point groups as collections of symmetry operations of molecules	Ap	PSO-1,2,3
CO-3	*identify* each spectroscopic method as the interaction of molecules with a characteristic radiation of the electromagnetic spectrum	An	PSO-1,2,3
CO-4	*apply* various spectroscopic techniques for the characterization of molecules.	Ap	PSO-2,3,4
CO-5	*justify* spectroscopic methods as unique tools for identifying molecules.	E	PSO-2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: THEORETICAL CHEMISTRY II

Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6	U	F	L	-

		PSO-1,2				
2	CO-2	PO-1,2,6 PSO-1,2,3	Ap	C	T	-
3	CO-3	PO-1,2,3,6 PSO-1,2,3	An	P	L/T	-
4	CO-4	PO-1,2,6 PSO-2,3,4	Ap	P	T	-
5	CO-5	PO-1,2,3,6,7 PSO-2,3,4,5	E	M	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PS O4**	**PSO 5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	3	3	-	-	-	2	-	-	-	-	3	-	-
CO 2	3	3	2	-	-	2	1	-	-	-	3	-	-
CO 3	3	3	2	-	-	2	2	1	-	-	3	-	-
CO 4	-	3	3	2	-	2	1	-	-	-	3	-	-
CO 5	-	3	3	2	2	2	2	3	-	-	3	2	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓
CO 5			✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSCCHE304**				
Course Title	**PHYSICAL CHEMISTRY IV**				
Type of Course	**DSC**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. A solid understanding of general chemistry principles, including thermodynamics, kinetics, equilibrium concepts and basic principles of quantum mechanics. 2. Proficiency in mathematics, particularly calculus and algebra, is required.				
Course Summary	The course covers a range of topics in chemical kinetics, catalysis, chemical and ionic equilibria, photochemistry and non-spectroscopic methods of analysis. Students will gain theoretical knowledge in understanding and applying fundamental principles in these areas, preparing them for careers in higher studies, research, or industry in the field of chemistry. It includes an open-ended module focusing on problem-solving, seminars, discussions, and other interactive learning methods to enhance students' critical thinking and analytical abilities.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**PHASE EQUILIBRIA**		**12**
	1	Phase Equilibria: Terminology, the phase rule, thermodynamic derivation of phase rule	1
	2	Application to water system and sulphur system	2
	3	Solid-liquid equilibria involving simple eutectic system such as Pb-Ag system, KI-water system	2
	4	Application to solid-liquid equilibria involving simple eutectic system such as Pb-Ag system, KI-water system, freezing mixtures, thermal analysis and desilverisation of lead	2
	5	Solid-liquid equilibria involving compound formation with congruent and incongruent melting points: $FeCl_3$- H_2O system and Na_2SO_4-H_2O system, solid–gas system- decomposition of $CaCO_3$, dehydration of $CuSO_4.5H_2O$, deliquescence and efflorescence.	5
II	**CHEMICAL KINETICS & CATALYSIS**		**12**

	6	Rate of reaction, rate constant, unit of rate constant, order and molecularity, Derivation of integrated rate equation of zero, first, second and nth order reaction	2
	7	Determination of order of reactions: Graphical and analytical methods using integrated rate equations, Fractional life- method, Differential rate equation method, Isolation method.	2
	8	Qualitative idea of Complex reactions: (a) opposing reactions (b) first order consecutive reactions (c) parallel reactions. Qualitative idea of chain reactions.	2
	9	Influence of temperature on rate of reaction: Arrhenius equation, Determination of Arrhenius parameter, Energy of activation and its significance.	2
	10	Collision theory, Derivation of the rate equation for a second order reaction based on collision theory, unimolecular reactions- Lindemann mechanism, steady state approximation.	2
	11	Catalysis: Theories of catalysis, Intermediate compound formation theory, steady state method, Enzyme catalysis, Michaelis-Menten law.	2
III	**CHEMICAL AND IONIC EQUILIBRIA**		**12**
	12	Equilibrium constant and free energy. Thermodynamic derivation of law of mass action, relation between Kp, Kc and Kx	2
	13	Le-Chatelier's Principle – Application in Haber process and dissociation of PCl_5	2
	14	Reaction isotherm, Temperature dependence of equilibrium constant, Pressure dependence of equilibrium constant. Application of Clausius-clapeyron equation in physical equilibria.	2
	15	Ionic equilibrium: Ionic product of water, Effects of solvents on ionic strength, levelling effect, pKa and pKb values, solubility product and common ion effect and their applications, pH and its determination by indicator methods, buffer solution, buffer action, Henderson's equation, buffer capacity	4
	16	Hydrolysis of salts of all types, degree of hydrolysis and hydrolytic constant, determination of degree of hydrolysis, relation between hydrolytic constant and ionic product of water	2
IV	**PHOTOCHEMISTRY & NON-SPECTROSCOPIC METHODS OF ANALYSIS**		**12**
	17	Grothus-Draper, Beer- Lambert and Stark- Einstein laws - Quantum yield, Reason for very low and very high quantum yields, Rate equation for decomposition of hydrogen iodide, Qualitative treatment of H_2-Cl_2 reaction and H_2-Br_2 reaction - Fluorescence and phosphorescence, chemiluminescence and photosensitization, Explanation and examples.	3
	18	Dipole moment, Debye equation and Clausius-Mosotti equation, measurement of dipole moment by temperature method, Dipole moment and molecular structure.	2
	19	Diamagnetism and paramagnetism, Magnetic susceptibility and unpaired electrons, measurement of magnetic susceptibility,	1

	20	Molar refraction and molecular structure, Atomic refraction, Optical exaltation, Parachor and atomic equivalent of parachor.	1
	21	Thermal methods- introductory aspects of TG, DTA and DSC Instrumentation and applications.	2
	22	Tools for measuring nanostructures: XRD, AFM, STM, SEM and TEM	3
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
	23	Open discussions on 1. Real life examples involving phase equilibria 2. Wide range of applications of phase equilibria in industries 3. Presentations of phase diagrams of other systems by students 4. Problems solving sessions 5. Any similar learning methods suggested by the faculty based on I-IV modules.	

References:

Textbooks

1. Puri, Sharma & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co
2. *Elements of Physical Chemistry*, Glasstone and Lewis, Macmillan
3. P. C. Rakhit, *Physical Chemistry*, Sarat Book House, Calcutta
4. R L Madan, *Physical Chemistry*, Mc Graw Hill

For Further Reading

1. R J Selby and RA Alberty, *Physical Chemistry*, John Wiley &sons
2. Levin, *Physical Chemistry*, 5th edn, TMH.
3. Bahl, Arun Bahl and G D Tuli, *Essentials of Physical Chemistry*, S Chand Ltd
4. S. C. Anand, *A text book of Physical Chemistry*, New Age International publishers.
5. Gurdeep Raj, *Advanced Physical Chemistry*, Goel publishing house

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Provide an understanding of phase equilibria principles, enabling to analyze and predict equilibrium conditions in complex chemical systems, useful for industrial processes and research in materials science.	U, An	PSO-1,2,3
CO-2	Equips with a reflective knowledge on reaction kinetics, and catalysis, to analyze and predict reaction rates in various chemical systems.	U, An	PSO-1,2,3

CO-3	Covers the principles of chemical and ionic equilibrium, essential for understanding and optimizing chemical processes.	U, An	PSO-1,2,3,4
CO-4	Acquire a thorough understanding of photochemical processes and their uses, which is necessary to assess and create chemical systems for use in industry and research.	U, Ap	PSO-1,2,3,4
CO-5	Discover how to analyze and design sophisticated materials for a range of applications by developing a thorough understanding of molecular and material properties.	An, Ap	PSO-1,2,3,4
CO-6	Learn the analytical skills and practical knowledge needed to handle challenging problems in chemical processes and industrial applications through problem-solving sessions, student presentations, industry applications, and other comparable approaches.	E, C	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHYSICAL CHEMISTRY IV

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U, An	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	U, An	F. C	L	-
3	CO-3	PO-1,2,6 PSO-1,2,3,4	U, An	F, C	L	-
4	CO-4	PO-1,2,3,6 PSO-1,2,3,4	U, Ap	P	L/T	-
5	CO-5	PO-1,2,3,6,7 PSO-1,2,3,4	An, Ap	P	L/T	-
6	CO-6	PO-1.2,3,6,7	E, C	P, M	-	P

		PSO-1,2,3,4,5				

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	1	-	-	-	-	3	-	-
CO 2	3	3	2	-	-	2	1	-	-	-	3	-	-
CO 3	3	3	2	1	-	2	1	-	-	-	3	-	-
CO 4	3	3	2	1	-	2	1	1	-	-	3	-	-
CO 5	2	2	3	2	-	2	1	1	-	-	3	-	-
CO 6	3	3	3	2	2	3	2	2	-	-	3	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSCCHE305**				
Course Title	**ORGANIC CHEMISTRY V**				
Type of Course	**DSC**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. UK2DSCCHE100, UK4DSCCHE202, UK5DSCCHE304				
Course Summary	The organic nitrogen compounds section covers the chemistry of nitro compounds, amines, amino acids, proteins, nucleic acids, heterocyclic compounds, dyes, terpenes, alkaloids, vitamins, and lipids, providing comprehensive insights into their structures, properties, synthesis methods, and applications in pharmaceuticals, dyes, and natural products. Additionally, the study of drugs and pharmaceuticals encompasses the structural elucidation, modes of action, synthesis, and uses of various medications, enhancing understanding of their therapeutic roles and chemical properties in medicinal chemistry.				

Detailed Syllabus:

Module	Unit	Content ORGANIC CHEMISTRY V	60 Hrs
I	**ORGANIC NITROGEN COMPOUNDS**		**12**
	1	Nitro compounds: Nitro – aci tautomerism, Nef's reaction. Reduction of nitrobenzene in various media. Preparation of nitro toluenes, nitro compounds as explosives.	2
	2	Amines: Classification – Preparation: From alkyl halides, nitro compounds, nitriles, isonitriles and amides – Hoffmann's bromamide reaction, Schmidt reaction, Gabriel phthalimide synthesis.	2
	3	Chemical properties: Carbylamine reaction, conversion of amines to alkene (Hoffmann elimination with mechanism), acylation, reaction with nitrous acid and Mannich reaction.	2
	4	Electrophilic substitution reactions of aniline: halogenation, sulphonation and nitration by amino protection (acetylation). Benzidine rearrangement (mechanism expected).	2

	5	Separation of mixture of amines – methods to distinguish primary, secondary and tertiary amines. Distinction between aliphatic and aromatic amines.	2
	6	Preparation and synthetic applications of diazonium chloride and diazomethane	2
II	**AMINO ACIDS, PROTEINS AND NUCLEIC ACIDS**		**12**
	7	Amino acids – classification – acidic, basic and neutral-essential and non-essential with examples	3
	8	Structure and stereochemistry of amino acids, zwitterion, isoelectric point**.**	2
	9	Synthesis of amino acids – Strecker synthesis, Gabriel phthalimide synthesis, Erlenmeyer azlactone synthesis. Reactions of amino acids – amino-salt formation, acetylation, reaction with nitrous acid, and HI COOH group- salt formation, esterification, reduction, acid chloride formation. Peptides: Structure and synthesis (Carbobenzoxy, Sheehan and solid phase synthesis)	3
	10	Proteins – classification of proteins – structure of proteins – primary, secondary, tertiary and quaternary, denaturation and colour reactions.	2
	11	Nucleic acids: Classification, structure of DNA and RNA. Replication of DNA. Transcription and Translation - Genetic code.	2
III	**HETEROCYCLIC COMPOUNDS AND DYES**		**12**
	12	Heterocyclic compounds- classification, nomenclature, aromaticity. Basicity of pyridine and pyrrole.	3
	13	Preparation - Paal-Knor synthesis and Hantzsch synthesis and properties of furan, pyrrole, thiophene and pyridine – electrophilic substitution reactions. Basicity of pyridine and pyrrole. Nucleophilic substitution of pyridine	3
	14	Condensed heterocycles- indole, quinoline, isoquinoline –preparation – Skraup (quinoline), Fischer-Indole (indole), Bischler-Napieralski synthesis (isoquinoline), reactions: electrophilic and nucleophilic substitution with directive effect	3
	15	Dyes: Theory of colour and constitution, classification according to structure and method of application. Preparation and uses of 1) Azo dye - methyl orange, 2) Phthalein dye - phenolphthalein, 4) Xanthen dye - fluorescein, Optical brightners – Introduction and important characteristics	
IV	**NATURAL PRODUCTS**		**12**
	16	Terpenes – Classification, general methods of isolation, - Isoprene rule - Essential oil examples	2
	17	Structure (no structural elucidation) and uses of citral, geraniol, limonene and menthol. Structure of natural rubber – vulcanization and its advantages.	2
	18	Alkaloids – Extraction. Structure and importance of nicotine, quinine, morphine and codeine.	2
	19	Structural elucidation of Nicotine and Conine.	2

	20	Vitamins: Classification, structure, functions and deficiency diseases (structure of vitamin A, B1 and C only - no structural elucidation).	2
	21	Lipids – biological functions – oils and fats - Common fatty acids	1
	22	Hydrogenation, rancidity, saponification value, iodine value and acid value.	1
V	**DRUGS AND PHARMACEUTICALS (Open ended module- This portion can be substituted by any other topics as selected by the teacher and can be evaluated by any method of teacher's choice)**		**12**
	23	Drugs – introduction – classification on the basis of application	4
	24	Structure and uses of sulphanilamide, sulphathiazole, sulphapyridine, Mode of action of sulfa drugs and ampicillin. Elementary idea of the structure and applications of chloroquine, ibuprofen, phenobarbital and benzyl pencillin	4
	25	Synthesis and uses of aspirin, paracetamol and chloroquin.	4

References

Text books

1. A.Bahl and B.S.Bahl, Advanced Organic Chemistry, S.Chand & Company, New Delhi.
2. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, A textbook of Organic Chemisty, Vikas Publishing House (Pvt) Ltd., New Delhi..
3. S.C.Sharma and M.K.Jain, Modern Organic Chemistry, Vishal Publishing Company, New Delhi..
4. I L Finar, "Organic Chemistry" Vol – 1&2, 5th Edition, Pearson Education, New Delhi.
5. Gowariker V.R., Viswanathan N.V. and Jayader Sreedhar, Polymer Science,Wiley Eastern Ltd, New Delhi.
6. O.P.Agarwal, Chemistry of Natural Products, Goel Publications.
7. T.L.Gilchrist, Heterocyclic Chemistry, Pearson Education, New Delhi.
8. AshuthoshKar, Medicinal Chemistry, New Age International Publishers.

For Further Reading:

1. R.T.Morrison, R.N.Boyd. Organic Chemistry, Pearson Education, New Delhi.
2. P.Y.Bruice, Essential Organic Chemisty, Pearson Education, New Delhi.
3. J.Clayden, N.Greeves and S.Warren, Organic Chemistry, Oxford University Press, New York.
4. Billmeyer F.W., Text book of Polymer Science, John Wiley and Sons.
5. S.P.Bhutani, Chemistry of Biomolecules, Ane Book Pvt Ltd.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Describe the methods of preparation, properties and identification tests of nitro and amino compounds.	U	PSO-1
CO-2	Classify and synthesise biomolecules such as amino acids, proteins and nucleic acids	R, U	PSO-1,2,3
CO-3	Outline the chemistry of simple heterocyclic compounds and dyes.	U,An	PSO-1
CO-4	Describe isolation methods and structure of various natural products such as terpenes, alkaloids, vitamins and lipids.	Ap, An	PSO-1,2,3
CO-5	Understand the structure and applications of various drugs and pharmaceuticals.	Ap, An	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ORGANIC CHEMISTRY V

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1	U	F	L	-
2	CO-2	PSO-1,2,3	R, U	F, C	L	-
3	CO-3	PSO-1	U	C	L	-
4	CO-4	PSO-1,2,3	Ap, An	F, C	L	-
5	CO-5	PSO-1,2,3,4,5	Ap, An	F	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	2	3	3	-	-	2	2	-	-	-	-	-	-

CO 3	2	-	-	-	-	2	2	-	-	-	-	-	-
CO 4	2	2	-	3	-	2	2	-	-	-	-	-	-
CO 5	2	2	3	3	3	2	2	3	-	-	3	2	2

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5	✓	✓	✓	-

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE300**				
Course Title	**ENVIRONMENTAL CHEMISTRY V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4	-	-	4
Pre-requisites	1. Prior Knowledge of classification of waste 2. Basic knowledge of Disaster 3. UK3DSECHE200, UK4DSECHE200, UK5DSECHE300, UK5DSECHE301				
Course Summary	This course covers waste generation, Treatment and disposal methods. This course also gives information regarding the case studies of National disaster and disaster management				

Detailed Syllabus:

Module	Unit	Content **ENVIRONMENTAL CHEMISTRY V**	Hours **60**
I	**SOLID WASTE AND ENVIRONMENTAL IMPACTS**		**9**
	1.1	Introduction; solid waste & its characteristics	1
	1.2	Solid waste. Source, Composition and Classification-Domestic waste, Municipal Solid Waste (MSW), Industrial Solid Waste (ISW) and Biomedical Solid Waste (BSW), Agricultural, nuclear and e -waste.	3
	1.3	Environmental impact on human and plant health, water quality and aquatic life	2
	1.4	Environmental effect of mining waste and land degradation.	1
	1.5	Effect of land leachate on soil characteristics and ground water pollution	2
II	**SOLID WASTE MANAGEMENT**		**9**
	2.1	Objectives of solid waste management, Methods of collection of solid waste	2
	2.2	Disposal Methods- conservancy system, water carriage system and dilution method	2
	2.3	Management of Solid Waste – MSW: Vermi composting, sanitary landfill, incineration. BSW- incineration and plasma pyrolysis. ISW- high temperature incineration, pyrolysis and vitrification.	3

	2.4	Solid Waste Management by Biotechnology, Drawbacks in Waste Management Techniques	2
III	**RECYCLING, RECOVERY AND REUSE OF WASTE**		**9**
	3.1	Recycling, Recovery and Reuse of Paper, glass, plastic, rubber and waste oil	2
	3.2	Recovery of heavy metal ions from agricultural waste	1
	3.3	Concept of energy recovery from solid waste - refuse derived fuel (RDF)	1
	3.4	Different waste to energy processes- combustion, pyrolysis, landfill gas recovery (LFG), anaerobic digestion, gasification	2
	3.5	Waste management policies – MSW (management and handling) rules 2000, Hazardous waste management and handling rules 1989, BSW (Management and Handling) rules 1998.	2
	3.6	Ecofriendly or green products	1
IV	**DISASTERS AND DISASTER MANAGEMENT**		**18**
	4.1	Basic Concept of Disaster – Definition of hazard, vulnerability risk, disaster. Causative factors of disaster	2
	4.2	Classification of disaster – natural – flood, drought, landslide, tsunami, cyclone- causes, mitigation and management	3
	4.3	Manmade disaster – fire, industrial pollution, biological disaster, structural failure (Building and bridges), accidents (road, rail and water), dams	4
	4.4	Disaster Management - definition, components of disaster management cycle- crisis management and risk management	2
	4.5	Crisis Management-Quick relief, recovery and rehabilitation	2
	4.6	Risk management - risk identification and assessment, risk reduction in vulnerable areas. Risk transfer	2
	4.7	Disaster management related policies and Acts in India	2
	4.8	Environmental management and audit – Basic concept only	1
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
	1	Introduction to Solid waste-classification, storage and Disposal	
	2	3 R's concept of solid waste management	
	3	Waste Management policies	
	4	Classification of disaster	
	5	Concept of Disaster Management	

Reference

1. Balram Pani, Text Book of Environmental Chemistry, I.K International Publishing House Pvt Ltd
2. A.K De, Environmental Chemistry Seventh Edition, New Age International Publishers
3. Gray W. vanLoon & Stephen J. Duffy, Environmental Chemistry: A Global Perspective, Oxford University Press
4. H. Kaur, Environmental Chemistry, Pragati Prakashan

5. V.K Ahluwalia, Environmental Chemistry, Second Edition, Ane Books Pvt. Ltd.
6. Ronald A. Bailey, Herbert M. Clark, James P. Ferris, Sonja Krause, Robert L. Strong, Chemistry of the Environment, Second Edition, Academic Press
7. G S Sodhi, Fundamentals Environmental Chemistry, Second Edition, Narosa Publishing House.

Course outcome

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	comprehend the fundamentals of waste generation, collection, transportation, treatment, and disposal. This includes knowledge of various waste types, their characteristics, and the environmental and health implications of improper waste management.	R, U	1, 3
CO2	Develop skills in waste reduction strategies, such as source reduction, recycling, composting, and waste-to-energy technologies.	A	1,3
CO3	Students will gain insight into waste management systems at local, national, and global levels, including regulations, policies, and best practices.	U	1, 3
CO4	Develop comprehensive knowledge on various types of disasters, including natural disasters (e.g., earthquakes, hurricanes, floods) and man-made disasters (e.g., industrial accidents, terrorist attacks).	U	1, 3
CO5	understanding about the characteristics, causes, and impacts of each type of disaster.	U	1, 3
CO6	Gives an idea about ethical and legal aspects of disaster management, including issues related to human rights, audits, equity, and accountability.	A	1, 3, 5

Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY V

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO1	1,2,3	R, U	F, C	L	
2	CO2	1,3	A	F, C	L	
3	CO3	1,3	U	F, C	L	

4	CO4	1,3	U	F, C	L	
5	CO5	1,3	U	F, C	L	
6	CO6	1,3,5	A	F, C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	1	1	-	-	1	1	-	-	-	-	-	-
CO 2	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 3	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 4	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 5	1	-	1	-	-	1	1	-	-	-	-	-	-
CO 6	1	1	1	-	-	1	1	-	-	-	-	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓			✓
CO 6	✓			✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK6DSECHE301</td></tr>
<tr><td>Course Title</td><td colspan="5">ENVIRONMENT CHEMISTRY VI</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">6</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 - 399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. Foundational understanding of green chemistry
2. Fundamentals of green synthesis
3. UK3DSECHE200, UK4DSECHE200, UK5DSECHE300, UK5DSECHE301, UK6DSECHE300</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides students with an in-depth understanding toxicology of substances and give an insight into green technology adopted for clean environment</td></tr>
</table>

Detailed Syllabus:

<table>
<tr><th>Module</th><th>Unit</th><th>Content
ENVIRONMENT CHEMISTRY VI</th><th>Hrs
75</th></tr>
<tr><td rowspan="5">I</td><td colspan="2">INTRODUCTION TO TOXICOLOGY</td><td>9</td></tr>
<tr><td>1.1</td><td>Introduction- concept of Toxicology, chronic and acute effects, toxic chemicals in environment- Air, Water & Soil,</td><td>3</td></tr>
<tr><td>1.2</td><td>Dose response concept- LD 50, LC 50</td><td>2</td></tr>
<tr><td>1.3</td><td>Carcinogens-general aspects. Hazards from food additives.</td><td>2</td></tr>
<tr><td>1.4</td><td>Toxicology of pesticides, insecticides and organometallic compounds</td><td>2</td></tr>
<tr><td rowspan="4">II</td><td colspan="2">TOXICOLOGICAL EFFECTS</td><td>9</td></tr>
<tr><td>2.1</td><td>Toxicological effects- General characteristics, biochemical, physiological, reversible and irreversible effects. Effect on the immune system. Detoxification. Impact of toxic chemicals on enzymes.</td><td>4</td></tr>
<tr><td>2.2</td><td>Biochemical effects of As, Pb, Cd, Hg, CO, oxides nitrogen & Sulphur, ozone and PAN</td><td>3</td></tr>
<tr><td>2.3</td><td>Solutions to environmental problems- Prevention of pollution and design for eco-friendly environment.</td><td>2</td></tr>
<tr><td>III</td><td colspan="2">GREEN TECHNOLOGY AND GREEN CHEMISTRY-INTRODUCTION</td><td>18</td></tr>
</table>

	3.1	Introduction Definition and concepts, Green technology, green energy, green infrastructure, green economy and green chemistry. Green technologies in historical and contemporary perspectives. Successful green technologies: Wind Turbines, solar panel, 3 R's of green technology.	5
	3.2	Applications of green technology: Pollution reduction and removal, Flue gas desulfurization method, catalytic or thermal destruction of nitrogen oxides. energy efficient fume hoods, carbon capture and storage technologies.	4
	3.3	Need and goal of green chemistry, Twelve principles of green chemistry-Concept of atom economy and its calculations	4
	3.4	Tools of Green Chemistry- Green starting materials, green reagents, green reactions, green methodology and green chemical products - obstacles and progress of Green Chemistry	5
IV	**APPLICATIONS OF GREEN CHEMISTRY**		**9**
	4.1	Green reagents- dimethyl carbonate, polymer supported reagents. Green catalyst- acid catalyst, base catalyst, oxidation catalyst, photocatalyst, polymer supported catalyst, phase transfer catalyst and bio catalyst. Green solvents- super critical fluid system, aqueous solvent systems and ionic liquids	4
	4.2	Green chemistry in action- real world cases- CO2 as a blowing agent, super critical CO2 as a cleaning agent, poly lactic acid as a biodegradable polymer, closed loop recycling of PET, use of H2O2 as a bleaching agent	3
	4.3	Importance of green chemistry in day-to-day life, green chemistry in sustainable development	2
V	**SOIL AND WATER ANALYSIS PRACTICALS III**		**30**
	1	Determination of Acidity and Total Alkalinity of Water- Titration Method -Minimum 3 Samples	
	2	Hardness of Water – Temporary, Permanent and Total Hardness – Complexometric Titration Method – Minimum 4 Samples	
	3	Determination of Nitrogen content in soil by titrimetric method- Minimum 5 samples	
	4	Determination of Phosphorus content in soil by colorimetric method- Minimum 5 samples	
	5	Determination of potassium content in soil by colorimetric method- Minimum 5 samples	

Reference

1. Balram Pani, *Text Book of Environmental Chemistry*, I.K International Publishing House Pvt Ltd
2. A.K De, *Environmental Chemistry*, Seventh Edition, New Age International Publishers
3. H. Kaur, *Environmental Chemistry*, Pragati Prakashan
4. V.K Ahluwalia, *Environmental Chemistry*, Second Edition, Ane Books Pvt. Ltd.

5. Asim K. Das, *Environmental Chemistry with Green Chemistry*, Books and Allied (P) Ltd.
6. Paul T. Anastas, John C. Warner, *Green Chemistry: Theory and Practice*, Oxford University Press.
7. V. Kumar, *An Introduction to Green Chemistry*, Vishal Publishing Co.
8. Arceivala S.L, *Green Technologies: For a Better Future*, Mc-Graw Hill Publication
9. S.M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
10. S.S. Dara: *A Textbook of Engineering Chemistry*, S.Chand & Company Ltd. New Delhi

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Enable to understand of the basic principles of toxicology, including the mechanisms of toxicity, dose-response relationships, and factors influencing toxicity such as route of exposure and duration of exposure. General introduction to carcinogens	U	1,3
CO2	Relate the information about the fate and transport of chemicals in the environment, including processes such as degradation, bioaccumulation, and persistence, and their implications for environmental and human health.	U, A	1,3,4
CO3	Comprehensive understanding of the principles of green chemistry, including the design of safer chemicals, the use of renewable feedstocks, and the reduction or elimination of hazardous substances and waste.	U. Ap	1,3,4
CO4	Students should be able to apply green chemistry concepts and principles to the design and synthesis of chemical products and processes, with a focus on minimizing environmental impact and promoting sustainability.	Ap	1,2,3,4,5
CO5	Students should learn how to evaluate and compare alternative chemicals and technologies based on their environmental and health impacts, energy efficiency, and economic feasibility	A	1,3,5
CO6	Give an idea about analytical methods to assess various parameters determining soil and water quality	Ap	1,2,3,4

Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ENVIRONMENTAL CHEMISTRY VI

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO1	1,3	U	F, C	L	
2	CO2	1,3,4	U, A	F, C	L	
3	CO3	1,3,4	U, Ap	F, C	L	
4	CO4	1,2,3,4,5	Ap	C, M	L	
5	CO5	1,3,5	A	F, C	L	
6	CO6	1,2,3,4	Ap	F, C		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	1	-	-	-	-	-	-	-	-	-	-
CO 2	1	-	1	2	-	-	-	-	-	-	-	-	-
CO 3	1	-	2	2	-	-	-	-	-	-	-	-	-
CO 4	2	2	1	1	1	-	-	-	-	-	-	-	-
CO 5	1	-	1		1	-	-	-	-	-	-	-	-
CO 6	1	2	1	1	1	-	-	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4	✓			✓
CO 5	✓			✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE302**				
Course Title	**CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY -V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Serve as a foundation for understanding the concepts and principles covered in a course on Advancements in Energy Storage Technologies. 2. To ensure that students are adequately prepared to engage with the material at an advanced level. 3. UK3DSECHE201, UK4DSECHE201, UK5DSECHE302, UK5DSECHE302				
Course Summary	• Students will gain a thorough understanding of energy storage materials and technologies, including their principles, properties, and applications, enabling them to analyse and implement sustainable solutions. • Through exploration and engagement, students will develop critical thinking skills vital for addressing sustainability challenges in the field of energy storage.				

Detailed Syllabus:

Module	Unit	Content CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY -V	Hrs 60
I	**INTRODUCTION TO THE ENERGY STORAGE MATERIALS AND LITHIUM- ION BATTERIES**		**18**
	1.1	Properties and Requirements of Materials for Sustainable Energy Applications Key properties required for materials used in renewable energy devices: are conductivity, stability, durability, flexibility, and efficiency.	3
	1.2	Relationship between material properties and performance in solar cells, batteries, fuel cells, and energy storage systems. Materials selection criteria based on specific application requirements and environmental considerations	3
	1.3	Lithium-ion Batteries	3

		- Principles of lithium-ion battery operation and components: electrodes, electrolytes, and separators. - Materials requirements for lithium-ion battery electrodes: cathode materials (e.g., lithium cobalt oxide, lithium iron phosphate) and anode materials (e.g., graphite, silicon).	
	1.4	Materials requirements for lithium-ion battery electrodes: cathode materials (e.g., lithium cobalt oxide, lithium iron phosphate) and anode materials (e.g., graphite, silicon) Properties and chemical requirements of electrode materials	3
	1.5	Challenges and opportunities in enhancing the energy density, cycle life, and safety of lithium-ion batteries through advanced materials design	2
	1.6	Working chemistry of Lithium-Ion batteries	2
	1.7	Discussion on the limitations of lithium-ion batteries and the need for alternative energy storage solutions.	2
II	**SOLID-STATE BATTERIES**		9
	2.1	Introduction to solid-state battery technology and its potential advantages over conventional liquid electrolyte batteries.	3
	2.2	Materials for solid-state electrolytes: ceramic, polymer, and composite electrolytes	2
	2.3	Strategies for improving the conductivity, stability, and interface compatibility of solid-state electrolytes with electrode materials	2
	2.4	Working chemistry of Solid-State Batteries	2
III	**ENERGY STORAGE IN SUPERCAPACITORS AND FUEL CELLS**		9
	3.1	Supercapacitors: Significance of Electrochemical Energy Storage Principles of supercapacitor operation, Plot of Energy vs. power Density. Different Types of Supercapacitors: Electrochemical Double Layer Capacitor (EDLC), Pseudo capacitor, Hybrid Capacitor, Components of Supercapacitors	3
	3.2	Different Models of Electric Double Layer: Helmholtz model, Gouy-Chapman-Stern model Comparison of Supercapacitors and Batteries Different Applications	3
	3.3	Fuel Cells and Electrolysis Overview of fuel cell technologies: proton exchange membrane fuel cells (PEMFC), solid oxide fuel cells (SOFC), and alkaline fuel cells (AFC). Materials requirements for fuel cell electrodes, electrolytes, and catalysts. Applications of advanced materials in improving the efficiency, durability, and cost-effectiveness of fuel cells and electrolysis systems.	3
IV	**EMERGING MATERIALS AND FUTURE DIRECTIONS**		**9**
	4.1	Exploration of emerging materials and technologies for energy storage and conversion, including metal-organic frameworks (MOFs) and covalent organic frameworks (COFs)- basic principles, synthesis and applications. perovskite oxides, 2D materials and thin films-theoretical concepts-principles, synthesis and applications.	2

	4.2	Discussion on current research trends, challenges, and opportunities in the development of advanced materials for sustainable energy storage and conversion	2
	4.3	Perovskite Solar Cells Introduction to perovskite materials and their remarkable properties for solar energy conversion. Overview of recent advancements in perovskite solar cell technology, including efficiency improvements, stability enhancements, and scalability. Challenges and opportunities in commercializing perovskite solar cells for large-scale deployment in photovoltaic applications.	3
	4.4	Case studies highlighting successful material innovations and their potential impact on the commercialization of next-generation energy storage and conversion devices	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		12
	1.	To understand the importance of energy storage in the context of transitioning to a sustainable energy future.	
	2.	To explore the fundamental principles and mechanisms underlying different energy storage technologies.	
	3.	To examine the applications of energy storage systems in various sectors, including renewable energy integration, transportation, grid stabilization, and off-grid solutions.	
	4.	To analyze the environmental, economic, and social implications of energy storage technologies.	
	5.	To assess the current challenges and limitations facing energy storage deployment and identify potential solutions.	
	6.	To investigate the latest research developments and emerging trends in energy storage materials, devices, and systems.	
	7.	To cultivate critical thinking, problem-solving, and communication skills through discussions, presentations, and collaborative projects.	

References:

1. Sen, Kalyan K., & Sen, Mey Ling. (2004). *Introduction to the Energy Storage Materials*. Wiley-IEEE Press.
2. Ramar, S., & Kuruseelan, S. (2013). *Power System Analysis*. Prentice Hall India Learning Private Limited.
3. Lu, Li. (2017). *Recent Advances in Energy Storage Materials and Devices* (Materials Research Foundations). Materials Research Society.
4. Wu, Yuping. (2015). *Lithium-Ion Batteries: Fundamentals and Applications* (Electrochemical Energy Storage and Conversion). CRC Press INC.
5. Warner, John T. (2015). *The Handbook of Lithium-Ion Battery Pack Design Chemistry, Components, Types and Terminology*. Elsevier Science, U.S.A.

6. Tripathi, P.K.. (2022). *Handbook on Production, Recycling of Lithium Ion and Lead-Acid Batteries* (with Manufacturing Process, Machinery Equipment Details & Plant Layout). NIIR project consultancy services.
7. Yu, Aiping, Chabot, Victor, & Zhang, Jiujun. (2013). *Electrochemical Supercapacitors for Energy Storage and Delivery*. CRC Press.
8. Jun, Hieng Kiat, & Low, Foo Wah. (2024). *Materials for Energy Conversion and Storage*. CRC Press.
9. Dudney, Nancy J, West, William C, & Nanda, Jagjit. (2015). *Handbook Of Solid-State Batteries* (2nd Edition). World Scientific.
10. Freund, L. B., & Nielsen, S. G. (2010). *Thin Film Materials: Stress, Defect Formation and Surface Evolution* (2nd Edition). Cambridge University Press.
11. Castro Neto, A. H., Chhowalla, L., & Ozyilmaz, B. (2019). *Two-Dimensional Materials*. Cambridge University Press.
12. Yaghi, Omar M., & Jones, Christopher W. (2022). *Covalent Organic Frameworks*. ACS Publications.
13. Yaghi, O. M., Li, G., & Deng, H. (2018). *Introduction to Metal-Organic Frameworks*. RSC.
14. Hoogers, G. (2003). *Fuel Cell Technology Handbook*. CRC Press.
15. Culp Jr., A. W. (1996). *Principles of Energy Conversion*. McGraw Hill.
16. Singh, Shobh Nath. (2018). *Non-Convention Energy Resources*. Pearson.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students will develop a comprehensive understanding of the fundamental principles underlying energy storage, including energy conversion, storage mechanisms, efficiency considerations, and application-specific requirements.	U	1,3
CO-2	Upon completion, students should be familiar with various battery technologies, such as lithium-ion batteries, lead-acid batteries, sodium-ion batteries, flow batteries, and solid-state batteries, and understand their respective advantages, limitations, and applications in different sectors.	R, U	1,3
CO-3	Students will be introduced to mechanical energy storage technologies, such as pumped hydroelectric storage, compressed air energy storage (CAES), flywheel energy storage, and gravity-based energy storage systems, and understand their operation, performance characteristics, and scalability for grid-scale energy storage applications	R, U	1,3

CO-4	Understanding the role of advanced materials, such as nanomaterials, 2D materials, carbon-based materials, and metal-organic frameworks (MOFs), in improving the performance, stability, and cost-effectiveness of energy storage devices is crucial for students to comprehend the latest advancements in energy storage technology development.	R, U, An	1,3
CO-5	To grasp the significance of energy storage for sustainable energy transitions and explore its fundamental principles, applications, and implications, while also analyzing challenges and emerging trends to foster critical thinking and problem-solving skills.	An, Ap	1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY -V

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	F, C	L	
2	CO-2	1,3	R, U	F, C	L	
3	CO-3	1,3	R, U	F, C, P	L	
4	CO-4	1,3	R, U, An	F, C, P	L	
5	CO-5	1,2,3,4	An, Ap	F, C, P, M	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	-	2	-	-	3	3	-	-	-	-	-	-
CO 2	2	-	3	-	-	3	3	-	-	-	-	-	-
CO 3	2	-	3	-	-	3	2	-	-	-	-	-	-
CO 4	3	-	3	-	-	2	3	-	-	-	-	-	-
CO 5	2	3	1	3	-	2	3	-	-	-	-	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓	✓	

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK6DSECHE303</td></tr>
<tr><td>Course Title</td><td colspan="5">CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY -VI</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">6</td></tr>
<tr><td>Academic Level</td><td colspan="5">300-399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>3 hours</td><td>-</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1. To explore the fascinating realms of hydrogen energy and electroanalytical techniques
2. Developing critical thinking skills is important for designing experiments, troubleshooting issues, and interpreting complex electrochemical phenomena
3. UK5DSECHE302, UK5DSECHE303</td></tr>
<tr><td>Course Summary</td><td colspan="5">• This course delves into hydrogen energy and fuel cell systems, addressing hydrogen production, storage, safety, green production methods, battery storage, and practical applications.
• Students gain both theoretical knowledge and hands-on experience, understanding hydrogen's potential as an energy carrier and its applications in renewable energy systems.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content **CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY -VI**	Hrs 75
I	**HYDROGEN ENERGY REVOLUTION AND FUEL CELL SYSTEMS**		**9**
	1.1	Introduction to hydrogen and the potential of hydrogen. Understand the basic properties of hydrogen, including its chemical and physical characteristics, and its role as an energy carrier. Hydrogen Energy- Introduction to hydrogen economy, hydrogen from fossil fuels, electrolysis of water, thermo-chemical cycles, transmission and infrastructure requirements, economics of transition to hydrogen systems. Applications of hydrogen.	3
	1.2	Hydrogen utilization- Fuel Cells Concept- Introduction, Working Principle, types of fuel cells, advantages and drawbacks, applications, integration with other renewable energy sources. Key components, physical and chemical phenomena in fuel cells, advantages and disadvantages, and characteristics, relation of the fuel consumption versus current output.	3

	1.3	Fuel Cells -Application and Economics- Fuel cell usage for domestic power systems, large-scale power generation, automobile, space applications, economic and environmental analysis on usage of fuel cell. Future trends of fuel cells Introduction, Hydrologic cycle, Climate and water availability, Water balances. Introduction to Hydro Power Energy: Introduction to non-conventional energy. Need for hydropower energy and its power estimation. Introduction & Components of Hydroelectric Power Plant, Functional requirements of water resources projects, steps in water resources planning, Environmental aspects in water resources planning.	3
II	**HYDROGEN PRODUCTION AND STORING METHODS OF HYDROGEN**		**9**
	2.1	Hydrogen Generation Methods: Steam methane reforming, Electrolysis (alkaline, PEM, and solid oxide electrolysis), Coal/Biomass Gasification, Solar and Wind-based Hydrogen Production, Emerging Hydrogen Generation Technologies, Photocatalytic Hydrogen Production-overview, Principle, Mechanism and Advantages.	3
	2.2	Energy storage systems overview - Scope of energy storage, needs and opportunities in energy storage. An overview of the three principal forms of hydrogen storage (gas, liquid, and solid), Gaseous hydrogen storage methods-Compressed Gas Storage, Liquid Hydrogen Storage, Chemical Storage (hydrogenation, metal hydrides), Physical Storage Using Nanostructured and Porous Materials.	3
	2.3	Safety Concerns of Hydrogen- Introduction - Identification, prevention, and mitigation of hydrogen hazards. Specific design considerations for hydrogen laboratories and experimental equipment. Risk Assessment and Mitigation Strategies, Case Studies of Hydrogen-related Incidents.	3
III	**HYDROGEN ENERGY AND ITS GREEN CHEMISTRY PRODUCTION, ELECTROANALYTICAL TECHNIQUES**		18
	3.1	Introduction to Green Hydrogen Production Methods definition and explanation to different methods of green Hydrogen production	1
	3.2	Green Hydrogen Production Methods: Electrolysis; Proton Exchange Membrane (PEM) Electrolysis: Alkaline Electrolysis, Alkaline electrolysis involves the electrolysis of water using an alkaline electrolyte, typically potassium hydroxide (KOH) or sodium hydroxide (NaOH). High-temperature electrolysis (HTE) using solid oxide electrolysis cells (SOECs).	3
	3.3	Solar Hydrogen Production: Solar thermal conversion: basics, Solar-driven electrolysis utilizes photovoltaic cells, Concentrated solar power (CSP)	1
	3.4	Wind Hydrogen Production: Principle of working of Wind Turbines Electrolysis. Hydrogen Generation Integration with Grid or Storage System Optimization, Advantages of Wind Hydrogen Production, Challenges of Wind Hydrogen Production. Hydroelectric Hydrogen Production; Methods and Procedure, Types, Hydroelectric Hydrogen Production Advantages	2

	3.5	Biomass Gasification: Feedstock Preparation process., Gasification Reactor Chemical Reactions, Syngas Composition process, Gas Cleaning and Conditioning, Utilization of Syngas	2
	3.6	The future of hydrogen: Decarbonization, Energy Storage, Fuel Cells. Industrial Applications, Infrastructure Development, International Collaboration.	1
	3.7	Introduction to Electrochemistry and Electroanalytical Techniques: Dynamic electrochemistry, Butler-Volmer and Tafel equations. Over potentials.	1
	3.8	Kinetically and mass transport controlled electrochemical processes. Mass transport (migration, convection, and diffusion), Solid state electrochemistry, potentiation, and galvanostatic methods.	2
	3.9	Electroanalytical techniques: Theoretical principles of electroanalytical chemistry, electrodes, polarization and depolarization, electrochemical cell, Electrode reactions, kinetics, reversibility and irreversibility.	2
	3.10	Electrochemical methods: ion-selective potentiometry, chrono amperometry, chrono coulometry, cyclic voltammetry, Differential pulse voltammetry, ion-transfer voltammetry, impedance spectroscopy.	2
	3.11	Instrumentation: rotating disk electrodes, microelectrodes, chemically modified electrodes, scanning electrochemical microscopy (SECM), EC-STM, and quartz crystal microbalance	1
IV	**BATTERY STORAGE**		**9**
	4.1	Battery Storage: Primary Batteries, Secondary Batteries, Stationary Systems: Flow Batteries and Thermal Batteries. Ni-hydrogen batteries for space and marine applications,	2
	4.2	Rechargeable batteries and their fundamental electrochemistry, Lithium batteries, Nickel metal hydride battery, Lead-acid battery, High-temperature batteries for backup applications, Flow batteries for load levelling and large-scale grid applications,	3
	4.3	Manufacturing technologies of batteries, Sustainable design of batteries, Hybridization of battery, Battery recycling technologies, Battery applications for stationary and secondary use	3
	4.4	Battery chargers and battery testing procedures, Battery management, Regulations and safety aspects of high voltage batteries.	1
V	**PRACTICALS ON ENERGY STORAGE TECHNOLOGY**		**30**
	1	Introduction of electroanalytical techniques	
	2	Preliminary arrangements of cyclic voltammetry analysis	
	3	Identify the defects and ionization energy in CuInGaSe2 thin film using temperature-dependent I-V measurement.	
	4	Evaluation of HOMO-LUMO levels of organic energy material using cyclic voltammetry.	
	5	Characterization of Battery- Charging Discharging efficiency	
	6	Determine the characteristics of a supercapacitor, Characterization of a Photo-electrochemical cell, Fuel cell characteristics	

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1. *Hydrogen Energy: Challenges and Prospects* by E. V. Ramasamy and P. S. Sundaravadivelu, PHI Learning Pvt. Ltd., 2012.
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3. *Fundamentals of Fuel Cell Science* by Alejandro A. Franco, Springer, 2020.
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7. *Renewable Hydrogen Technologies: Production, Purification, Storage, Applications, and Safety* by Luis M. Gandia and Gurutze Arzamedi, CRC Press, 2013.
8. *Wind Energy Explained: Theory, Design and Application* by James F. Manwell, Jon G. McGowan, and Anthony L. Rogers, Wiley, 2010.
9. *Biomass Conversion: The Interface of Biotechnology, Chemistry and Materials Science* by Chinnappan Baskar, Shree P. S. and Jeong-Myeong Ha, Springer, 2012.
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11. *Electroanalytical Chemistry: A Series of Advances*, Vol. 27 edited by Allen J. Bard, CRC Press, 2016.
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13. *Renewable Energy Resources and Their Applications* by H. P. Garg, S. C. Sharma, and R. P. Saini, PHI Learning Pvt. Ltd., 2010.
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15. *Solar Photovoltaics: Fundamentals, Technologies, and Applications* by Chetan Singh Solanki, PHI Learning Pvt. Ltd., 2014.
16. *Wind Energy: Fundamentals, Resource Analysis and Economics* by Sathyajith Mathew and Mohan Lal Kolhe, Springer, 2014.
17. *Biomass Energy Conversion: Principles and Practice* by P. Jayarama Reddy, PHI Learning Pvt. Ltd., 2013.
18. *Lithium-Ion Batteries: Basics and Applications* by K. R. V. Subramanian, CRC Press, 2017.
19. *Electrochemical Engineering* by G. T. Patil, Nirali Prakashan, 2016.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To understand the hydrogen energy, including hydrogen production methods, storage technologies, transportation	U	1,3

	systems, and utilization pathways.		
CO-2	To aware about hydrogen storage and transportation technologies, such as cryogenic tanks, metal hydride beds, Photocatalytic Hydrogen Production-overview, and their respective advantages, limitations, and energy efficiency, is important for students to evaluate the suitability of different storage and transportation options for various applications.	R, U	1,3
CO-3	Awareness of electrochemical energy conversion and storage technologies, such as fuel cells, batteries, supercapacitors, and electrolyzers, and the role of electroanalytical techniques in studying their performance, degradation mechanisms, and optimization strategies, is important for students to contribute to advancements in sustainable energy technologies	R, U, Ap	1,3
CO-4	Students should understand hydrogen production, storage, and utilization, along with the electrochemical methods used to analyze and optimize these processes	U	1,3
CO-5	To develop practical skills in electroanalytical techniques, cyclic voltammetry analysis, and characterization of various energy storage and conversion devices such as batteries, supercapacitors, and fuel cells. Through hands-on exercises, gain proficiency in identifying defects, evaluating energy material properties, and assessing the performance of energy storage technologies.	R, U, Ap,An	1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY FOR RENEWABLE AND CLEAN ENERGY -VI

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	CO-1	1,3	U	F, C	L	
2	CO-2	1,3	R, U	F, C, P	L	

3	CO-3	1,3	R, U, Ap	F, C, P	L	
4	CO-4	1,3	U	F, C, P, M	L	
5	CO-5	1,2,3,5	R, U, Ap, An	F, C, P, M		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	3	-	2	-	-	3	2	-	-	-	-	-	-
CO 2	2	-	3	-	-	3	2	-	-	-	-	-	-
CO 3	3	-	3	-	-	2	3	-	-	-	-	-	-
CO 4	2	-	3	-	-	3	2	-	-	-	-	-	-
CO 5	1	3	2	-	3	3	3	-	-	-	-	2	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓		✓
CO 5		✓		

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE304**				
Course Title	**ANALYTICAL CHEMISTRY- V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1.Prior knowledge of analytical chemistry principles, such as spectroscopy, interaction of Electromagnetic radiation with Molecules and materials, and titration techniques 2. Familiarity with Blood fluids 3. Understanding of electromagnetic radiation and microscopy principles. 4. UK3DSECHE202, UK4DSECHE202, UK5DSECHE304, UK5DSECHE304				
Course Summary	The course delves into various advanced topics in analytical chemistry, covering both traditional and modern techniques. Students explore, spectroscopic analysis, material characterization techniques, and the topic Green Analytical Chemistry				

Detailed syllabus:

Module	Unit	Content ANALYTICAL CHEMISTRY- V	Hrs 60
I	**SELECTED TOPICS IN ANALYTICAL CHEMISTRY**		**9**
	1.1	Food Chemistry**:** Analysis of milk and milk products: Composition of milk, analysis of milk with respect to pH, acidity, fates, casein content, lactose content, mineral content, adulteration of milk.	2
	1.2	Food Additives – General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes	2
	1.3	Clinical Chemistry: Blood- Composition, Collection and Preservation of Blood Samples, Clinical Analysis—Common Determinations,	2
	1.4	Immunoassay: Introduction, Principles, Specificity, Incubation Period for The Assay, Separation of the bound and free antigen, Fluorescence Immunoassay, Enzyme Immunoassay	3
II	**MATERIAL CHARACTERIZATION TECHNIQUES**		**9**

	2.1	Electromagnetic Radiation, Scanning Electron Microscopy (SEM) - principles, Imaging Modes, Energy Dispersive X-ray Spectroscopy (EDAX)- SEM: Applications, Limitations.	3
	2.2	Transmission Electron Microscopy (TEM) - principles, Imaging Modes, Applications, Limitations.	2
	2.3	Scanning Probe Microscopy (SPM) – Principles, Atomic Force Microscopy (AFM) - basic principles, instrumentation, operational modes, Applications, Limitations	2
	2.4	X-Ray Diffraction Technique: Principle, Instrumentation, Basics of Data interpretation, Introduction to Single crystal X Ray Diffraction.	2
III	**GREEN ANALYTICAL CHEMISTRY**		**9**
	3.1	Green Analytical Chemistry an Introduction, The Basics of Green Chemistry	2
	3.2	Green Metrics Commonly Applied throughout the Industry: Eco Footprint, E-factor, NEMI Labelling and Greener Analytical Methods, Greenness Profiles of Greener Analytical Methods	2
	3.3	Concept of green analytical Process: Basic concept of green sampling techniques, direct analysis of samples, green analytical approaches in sample preparation. Green strategies	5
IV	**SPECTROSCOPIC METHODS OF ANALYSIS II**		**18**
	4.1	Fluorometry: Principle of fluorometry, Chemical structure & fluorescence, Quenching, Relationship between concentration and fluorescence intensity, Instrumentation, fluorescence lifetime and gated fluorescence/phosphorescence measurement, fluorescence vs absorbance, chemiluminescence	4
	4.2	Atomic spectrometric methods: Distribution of atoms as a function of temperature, Flame emission spectrometry, Atomic absorption spectrometry, Flame AAS, Electrothermal AAS, Interferences in AAS, Sample Preparation, Internal standard and standard addition calibration	4
	4.3	Atomic emission spectrometry the induction-coupled plasma (ICP), Laser ablation ICP–optical emission spectrometry/mass spectrometry (ICP-MS), Atomic fluorescence spectrometry	4
	4.4	Spectroscopy Based on Scattering: Origin of Scattering, Turbidimetry and Nephelometry, Instruments for nephelometry and turbidimetry	6
V	**Open Ended Module: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc.**		**12**
	1.	Research and write a report on clinical chemistry focusing on blood composition and analysis.	
	2.	Discuss the importance of proper collection and preservation of blood samples and common determinations in clinical analysis.	
	3.	Explore the principles and applications of immunoassays, including fluorescence and enzyme immunoassay techniques.	
	4.	Discuss the feasibility and practicality of implementing green analytical strategies in the industry.	

	5.	Discuss the concepts of eco footprint, E-factor, and NEMI labeling in evaluating the environmental impact of analytical methods.	
	6.	Interpret imaging and xrd data.	
	7.	Explore the applications of immunoassays in clinical diagnostics and biomedical research.	
	8.	Explore case studies and examples of green analytical approaches in various industries.	
	9.	Explore the advantages and limitations of different spectroscopic methods for chemical analysis.	
	10.	Discuss the challenges of pH measurement in nonaqueous solvents and propose strategies to overcome these challenges.	
	11.	Propose greener alternatives or modifications to the method to reduce waste generation, energy consumption, and chemical usage.	

References

1. D. J. Homes and H. Peck, *Analytical Biochemistry*, Longman 1983.
2. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.
3. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
4. T. Pradeep, *NANO: The Essentials: Understanding Nanoscience and Nanotechnology*, Tata McGraw-Hill Publishing Company Limited, 1st Edition, 2007.
5. Miguel de la Guardia, Salvador Garrigues (E), *Handbook of Green Analytical Chemistry*, John Wiley & Sons, Ltd, 2012.
6. Lawrence H. Keith, Liz U. Gron, and Jennifer L. Young, *Green Analytical Methodologies*, Chem. Rev. 2007, 107, 2695−2708.
7. Marek Tobiszewski, Mariusz Marć, Agnieszka Gałuszka and Jacek Namieśnik, *Green Chemistry Metrics with Special Reference to Green Analytical Chemistry*, Molecules 2015, 20, 10928-10946; doi:10.3390/molecules200610928.
8. D. A. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.
9. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House.
10. Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F.A. Jr., *Instrumental Methods of Analysis*, CBS Publishers & Distributors, 7th Edition, 1986.
11. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Text book of Quantitative Inorganic Analysis*, Longman, Fifth Edition, 1989.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Understand the composition and collection of blood samples, clinical analysis techniques to common determinations.	U, Ap	1
CO-2	Understand the principles and applications of scanning electron microscopy (SEM), transmission electron microscopy (TEM), Scanning probe microscopy (SPM), including atomic force microscopy (AFM).	U	2
CO-3	Acquires knowledge about green analyticl chemistry including tools and techniques for assessing the greenness of methods.	U	2, 4
CO-4	Understands the principles of fluorometry at an advanced level, acquires knowledge about various atomic spectrometric methods and spectroscopy based on scattering.	U, Ap	2
CO-5	Applies and analyze the knowledge acquired through this course in practical situations.	Ap, An	2, 3 & 5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL CHEMISTRY V

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1 PSO-1	U, Ap	F	L	
2	CO-2	PO-1 PSO-2	U	C	L	
3	CO-3	PO-1 PSO-2 & 4	U	F, C	L	
4	CO-4	PO-1 PSO-2	U, Ap	C	L	
5	CO-5	PO-2, 3, 4 & 6 PSO-2, 3 & 5	Ap, An	M	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	1	-	-	-	-	-
CO 2	-	2	-	-	-	-	2	-	-	-	-	-
CO 3	-	2	-	2	-	-	2	-	-	-	-	-
CO 4	-	2	-	-	-	-	2	-	-	-	-	-
CO 5	-	3	3	-	3	-	-	3	2	3	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√			√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√			√
CO 5		√	√	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE305**				
Course Title	**ANALYTICAL CHEMISTRY- VI**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3hours	-	2	5
Pre-requisites	1. Basic knowledge of chemistry, including chemical reactions and analytical techniques. 2. Understanding of laboratory safety protocols and hazardous chemical handling. 3. Familiarity with environmental science concepts, including pollution sources and regulations 4. UK3DSECHE202, UK4DSECHE202, UK5DSECHE304, UK5DSECHE304				
Course Summary	This course provides a comprehensive overview of analytical chemistry techniques, and safety protocols essential for laboratory work and environmental analysis.				

Detailed Syllabus:

Module	Unit	Contents ANALYTICAL CHEMISTRY- VI	Hrs 75
I	**ENVIRONMENTAL SAMPLING**		**9**
	1.1	Getting a meaningful sample, Collecting air samples—General considerations, the sample train, sampling devices, Air sample analysis	3
	1.2	Collecting water samples—surface, groundwater	3
	1.3	Soil & Sediment Sampling, Sampling preparation for Trace organics	3
II	**AUTOMATION IN MEASUREMENTS & QUALITY ASSURANCE**		**9**
	2.1	Principles of Automation, Process Control: Continuous and Discrete Analyzers, Instruments used in automated process control, Automatic Instruments: Discrete sampling instruments & Continuous-flow sampling instruments, Flow Injection Analysis, Sequential Injection Analysis, Laboratory Information Management System	5

	2.2	Objective of Quality Assurance, Quality Control, Quality Assessment: Internal & External Methods, Evaluating Quality Assurance Data: Prescriptive Approach, Performance-Based Approach, Using Control Charts for Quality Assurance	4
III	**CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS**		**9**
	3.1	Being Safe in the Laboratory, Safety culture and Your role in it, Medical Emergencies, Fire, Proper Conduct/Behaviour in lab	1
	3.2	Personal Protective Equipment: Hair & Apparel for Laboratory, Eye protection, Gloves, Laboratory Protocols: Safe Handling of Chemicals & Equipment, Proper House Keeping, Proper Hygiene, Disposal of Chemicals, Electrical Safety, Fire Safety	2
	3.3	Emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure	3
	3.4	Safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	3
IV	**ENVIRONMENTAL ANALYSIS & MANAGEMENT**		**18**
	4.1	Air Pollution, Sources, classification, pollutants and permissible limits. Sampling methods for air, flew gas, Industrial Exhaust, stag samples etc. Importance of automobile exhaust control and its limits, Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapours.	3
	4.2	Soil Analysis: sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long-term effect on soil quality	4
	4.3	Environmental Audits: concept of audit, authorities, evaluation methodology, benefits and certification	2
	4.4	Water Quality Fundamentals, Physical and chemical properties, Important water Quality parameters and methods for their determination - Hardness testing, turbidity, colour, taste, pH, acidity, alkalinity, chemical constituents, hardness, dissolved oxygen, EC, DTC etc., water sampling, the standard for drinking water as per BIS specifications, household water treatment and safe storage	5
	4.5	Analysis of Water: Metals in water by AAS & ICPMS (Zn, Mg, Ca, Pb, Hg), Toxic Substances-Pesticides- Polychlorinated Biphenyls, Microbiological Parameters: Aerobic Microbial count, Detection of E.Coli and Coliform, Enterococci	4
V	**ANALYTICAL CHEMISTRY PRACTICALS III**		**30**
	A	**7 Experiments from Section A are compulsory**	15

		Water Analysis (chemical constituents, hardness, dissolved oxygen, EC, DTC) Physical & Chemical Parameters 1. To determine Total Alkalinity of Water 2. To determine the total hardness of the water sample 3. To determine pH and conductance of waste water 4. To determine Dissolved oxygen of waste water 5. To determine Biological and Chemical oxygen demand 6. To determine Acidity of Water 7. To determine TS, TSS, TDS of water 8. To determine salinity of the given water sample 9. Analysis of metals and ions 10. Microbiological analysis.	
	B	**Open ended: Any 3 experiments are to be conducted (May be selected from the list or the teacher can add related experiments)** Soil Analysis Sampling 1. Analysis of Physical Parameters: 2. Determination of Moisture Content 3. Water Holding Capacity, 4. Analysis of Chemical Parameters: 5. Analysis of Carbonate 6. Organic carbon and organic matter 7. Total nitrogen, ammonia and nitrates, 8. Total determination of major soil constituents by fusion analysis 9. Determination Ca, Mg, Na, K, phosphate, 10. Exchangeable cations, Cation exchange capacity	10
	C	Anaysis of Selected Food Materials **Milk Analysis:** 1. Detection of Added Water in Milk 2. Detection of Added Starch and Cereal Flours 3. Detection of Cellulose in Milk 4. Detection of Added Cane Sugar (Sucrose) 5. Detection of Added Glucose 6. Detection of Added Urea Detection of Preservatives added to Milk: 1. Formalin 2.Boric Acid and Borate 3.Benzoic and Sodium benzoate in Milk 4. Salicylic Acid	5

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1. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Saunders College Publishing, 7th edition, 1996.

2. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, *Analytical Chemistry* –, Wiley, 7th edition, 2013.
3. D. A. Skoog and D. M. West, *Principles of Instrumental Analysis*, Saunders College Publishing, 5th edition, 1998.
4. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis,* Himalaya Publishing House.
5. Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; *Settle, F.A. Jr., Instrumental Methods of Analysis,* CBS Publishers & Distributors, 7^{th} Edition, 1986.
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8. Sharad Gokhale, *Air Pollution Sampling and Analysis,* IIT Guwahati, May 2009.
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   OSU Safety manual 1.01
10. S. M. Khopkar, *Environmental Pollution Analysis,* New Age International publication, 2011.
11. *FSSAI Manual of methods of Analysis of Water,* Food Safety And Standards Authority of India, Ministry of Health And Family Welfare, Government of India, 2016
12. W. Horwitz (Editor), Official Method of Analysis of AOAC International, 18th Edn., AOAC, 2010
13. *FSSAI Manual of Simple methods for testing of common adulterants in food*, Food Safety And Standards Authority of India, Ministry of Health And Family Welfare, Government of India.
14. *Chemical Safety matters – IUPAC-IPCS,* (1992) Cambridge University Press.

Course Outcomes

No:	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the sampling methods	U	2
CO-2	Understands quality control methods and assessment techniques and applies the knowledge of quality assurance data evaluation methods using control charts.	U, Ap	2
CO-3	Acquires knowledge about safety protocols, procedures in the laboratory emergency procedures and first aid measures and understand safe storage and disposal of hazardous chemicals and waste.	R, U	4
CO-4	Understand air pollution sources, classification, and permissible limits, the importance of controlling automobile exhaust emissions.	U	2

CO-5	Understands soil & water analysis techniques including sampling,	U	2
CO-6	Applies the knowledge of Water and soil analysis techniques	Ap	2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ANALYTICAL CHEMISTRY VI

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-2 PSO-2	U	C	L	
2	CO-2	PO-2 PSO-2	U, Ap	P	L	
3	CO-3	PO-1 & 2 PSO-4	R, U	C	L	
4	CO-4	PO-2 PSO-2	U	C	L	
5	CO-5	PO-2 PSO-2	U	P	L	
6	CO-6	PO-2 & 6 PSO-2	Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	-	-	-	-	-	2	-	-	-	-
CO 2	-	2	-	-	-	-	-	2	-	-	-	-
CO 3	-	-	-	1	-	-	1	2	-	-	-	-
CO 4	-	2	-	-	-	-	-	2	-	-	-	-
CO 5	-	2	-	-	-	-	-	2	-	-	-	-
CO 6	-	2√	-	-	-	-	-	2	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	√			√
CO 2	√			√
CO 3	√	√		√
CO 4	√	√		√
CO 5	√		√	√
CO 6	√			

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE306**				
Course Title	**INDUSTRIAL CHEMISTRY- V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK3DSECHE203, UK4DSECHE203, UK5DSECHE306 UK5DSECHE307, UK6DSECHE307				
Course Summary	The course is designed to provide students with a comprehensive understanding of various aspects of Chemical Economics, Plant Design & Layout, Cost Estimation, Depreciation & Profitability Analysis, and Management & Entrepreneurship in Industrial Operations.				

Detailed Syllabus:

Module	Unit	Content INDUSTRIAL CHEMISTRY- VI	Hrs
I	**CHEMICAL ECONOMICS**		**9**
	1.1	Role of economic principles in the chemical industry-Key economic concepts: Supply and Demand	3
	1.2	Market equilibrium, Elasticity, and Concept of opportunity cost, Market structures: types and relevance	3
	1.3	Financial Health of Chemical Industries: Sources of funds, financial institutions, financial ratios and their significance, Books of accounts and Financial statements	3
II	**PLANT DESIGN, LAYOUT AND COST ESTIMATION**		**18**
	2.1	Basic considerations in chemical plant design; Optimization and feasibility of plant design; Factors affecting process selection	2
	2.2	Factors affecting plant location and plant layout; Importance of pilot plant for laboratory development, Safety measures considered for industrial plant	4
	2.3	Cost estimation - Cash flow pattern and cumulative cash flow for industrial operations; analysis of cost estimates: factors affecting investment and production costs	4
	2.4	Capital Investment- fixed & working capital: Types of Capital Cost Estimates; Cost Indices; Cost factors in capital investment; Methods for Estimating Capital Investment: Detailed-Item Estimate,	4

	2.5	Unit-cost estimate, percentage of delivered-equipment Cost, "Lang" factors for approximation of capital investment; estimation of total product cost- manufacturing costs & general expenses.	4
III	**DEPRECIATION AND PROFITABILITY ANALYSIS**		**9**
	3.1	Depreciation - Definition & Types of depreciation; methods for determining depreciation: straight line, declining balance	3
	3.2	Unit of production, sum of the years digits, sinking fund and accelerated cost recovery system, single-unit and group depreciation	3
	3.3	Profitability analysis- Profitability standards; methods for profitability evaluation- rate of return on investment, discounted cash flow analysis, break-even analysis, alternative investments and replacements in industries	3
IV	**MANAGEMENT & ENTREPRENEURSHIP IN INDUSTRIAL OPERATIONS**		**9**
	4.1	Resource management: men, machine and materials, Creativity & innovations, Problem-solving approach, SWOT analysis	2
	4.2	Aspects of marketing: quality control, quality assurance, and testing of products, packaging, advertising and after-sales service, constraints in small scale, emerging industries and their remedies, licensing & registration	2
	4.3	Entrepreneurship: concept & characteristics, Need and scope of entrepreneurship in industrial operations, barriers to entrepreneurship, managerial Vs. entrepreneurial approach, Innovation and 3ntrepreneurship	3
	4.4	Women entrepreneurs: growth and constraints, importance of sustainability, environmental and social responsibility in the chemical industry.	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, quizzes, open book exam etc.**		**12**
		1. Various aspects of plant design, cost estimation, depreciation, and profitability analysis. 2. Factors affecting plant location and plant lay. 3. Analyse the types of depreciation and methods for determining depreciation. 4. Case studies of women entrepreneurs. 5. Quality control, Quality assurance, and testing of products. 6. Factors affecting investment and production Costs 7. Alternative investments and replacements in industrie. 8. "Lang" factors for approximation of capital investment. 9. Cash flow pattern and cumulative cash flow for industrial operations. 10. Importance of sustainability, environmental, and social responsibility in the chemical industry.	

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3. James. R. Couper. (2003). *Process Engineering Economics*. CRC Press.
4. Peters, Max S., Klaus D. Timmerhaus, and Ronald E. West. (2002). *Plant Design and Economics for Chemical Engineers*. McGraw-Hill Chemical Engineering Series. New York, NY: McGraw-Hill Professional.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Display a thorough grasp of economic principles, key concepts, and market structures, along with the ability to interpret financial statements, evaluate financial health, and make well-informed financial judgments for chemical enterprises.	U, E, Ap	1,2,3
CO-2	Gain expertise in chemical plant design, optimizing layouts, and selecting processes.	U,Ap	1,2,5
CO-3	Estimate project costs, assess capital investments, and utilize suitable financial methodologies for analysis.	E	1,2,3
CO-4	Utilize appropriate financial techniques to assess profitability.	E	1,2,3
CO-5	Cultivate skills in resource management, problem-solving, and innovation crucial for achieving entrepreneurial success in industrial settings	Ap,An	1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INDUSTRIAL CHEMISTRY- VI

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2,3	U,E,Ap	C, P	L	

2	CO-2	1,2,5	U, Ap	C, P	L	
3	CO-3	1,2,3	E	C, P	L	
4	CO-4	1,2,3	E	C, P	L	
5	CO-5	1,2,3	Ap, An	C, P, M	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	3	-	-	3	3	-	2	2	-	-	-
CO 2	3	2	-	-	3	3	3	3	-	-	-	3	-
CO 3	1	2	3	-	-	3	3	-	-	-	-	-	-
CO 4	3	3	2	-	-	3	3	-	1	-	-	-	-
CO 5	2	3	3	-	-	3	3	-	-	3	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓	✓	✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE307**				
Course Title	**INDUSTRIAL CHEMISTRY- VI**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK5DSECHE306 UK5DSECHE307 UK6DSECHE306				
Course Summary	The course provides students with a comprehensive understanding of dyes and polymers, their industrial applications, and relevant theoretical concepts, preparing them for careers in industries related to textiles, chemicals, plastics, and materials science.				

Detailed Syllabus:

Module	Unit	Content INDUSTRIAL CHEMISTRY- V	Hrs
I	**DYES**		**9**
	1.1	Basic Concepts, nomenclature and classification as per their chemical constitution and mode of dyeing. Classification with special reference to textile and edible dyes, methods of dyeing, acid, direct, reactive, disperse, vat, cationic, Sulphur dyes, indigo –azo dyes.	4
	1.2	Introduction to natural dyes and its importance in cotton textile dyeing, Synthetic dyes - A brief idea of metal complex dye stuffs, fluorescent and brightening agents –hair dyes –dyeing standards and health hazards	2
	1.3	Industrial preparation and uses of methyl orange, congo red, crystal violet, phenolphthalein, fluorescein, malachite green, indigo and alizarin.	3
II	**INTRODUCTION TO POLYMERS**		**9**
	2.1	Basic concepts- historical development- present status-classification of polymers-natural and synthetic polymers- organic and inorganic polymers, thermoplastics and thermo sets- plastics, elastomers, fibers and liquid resins	3
	2.2	Basic concept of monomers-functionality, Addition polymers and condensation polymers-homopolymers and copolymers- linear, branched and cross-linked polymers, graft and block co-polymers, characteristic features of each,	3

	2.3	Molecular weight of polymers – Number average, weight average, degree of polymerization -polydispersity and PDI, properties of polymers, glass transition temp(Tg)	3
III	**INDUSTRIAL MANUFACTURE AND PROCESSING OF POLYMERS AND CHARACTERIZATION OF POLYMERS**		**18**
	3.1	Synthesis, chemistry, properties and applications of the following Thermoplastics polymers: Polyethylene – HDP, LDP, LLDP, polyvinyl chloride, teflon. polystyrene – SBR, ABS, SAN, vinyl polymers – PVA, PVB, polyacetals, polyamides – nylon-6, nylon-66	4
	3.2	Thermosetting polymers: phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, polyurethanes	2
	3.3	Polymer processing-moulding, compounding, blending	2
	3.4	Molecular weight determination – Method based on colligative property measurements – cryoscopy, ebullioscopy, osmometry, membrane osmometry	4
	3.5	Methods of determination of molecular weight of polymers –viscometry – Light scattering method –ultracentrifuge technique –End group analysis – GPC method.	3
	3.6	Thermal methods of analysis in polymers – TGA, DTA, DSC.	3
IV	**INORGANIC POLYMERS**		**9**
	4.1	General properties of inorganic polymers –classification –boron-based polymers – borazine, polymeric boron nitride	3
	4.2	Phosphorous based polymers, polyphophonitrilic chloride –poly phosphoric acids–phosphorous based network polymers	3
	4.3	Silicon based polymers – silicones; Sulphur containing polymers (SN)x.	3
V	**PRACTICALS** **A minimum of five practical from any sections must be performed and reported**		**30**
		SECTON A Determination of following contents in a sample of polymer 1. Ammonia content 2. Total solid content 3. Dry rubber content 4. KOH number	10
		SECTON B 1. Acid value 2. Iodine value 3. Estimation of hydroxyl groups 4. Estimation of nitrogen in polymeric and related sample	10
		SECTON C 1. i) Preparation of dyes: a. Fluorescein b. Eosin c. Methyl orange d. Mordant Yellowe. e. Fast green f. Orange I 2. TLC of a mixture of dyes (safranine-T, Indigo carmine, methylene blue) 3. Estimation of Methyl Orange/Eriochrome Black T/Congo Red by colorimetry)	10

References

1. *Industrial Chemistry 10th edition* B. K Sharma, Goel Publishing House, Meerut, India
2. *Shreve's Chemical Process Industries* (5th ed.). G. T. Austin.
3. *Textbook of Polymer Science*, Fried W. Bllmeyer. Hoboken, NJ: John Wiley & Sons.
4. *Physical Chemistry of Macromolecules*, D. D Deshpande, Vishal Publications, New Delhi
5. *Polymer Science*, V.R. Gowarker, N.V. Viswanathan and J.Sreethan Wiley Eastern Ltd, 1986
6. *A Course in Industrial Chemistry*, Ayyankar, N. R. & Hegde, M. V.
7. *Chemistry of Synthetic Dyes*, Venkataraman, K. Vol. I-VI.
8. *Polymer Science*. Gowarikar, V. R. (1986), Wiley Eastern Ltd.
9. *Organic Chemistry (Vol. I)*, I. L Finar

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the principles and methods of dyeing and their applications in industries.	U	1,3
CO-2	Identify and classify polymers based on their characteristics for different practical uses.	U	1,3
CO-3	Explain the process of polymer synthesis and manufacturing in industrial settings.	R	1,2,3
CO-4	Perform polymer characterization techniques to analyze and interpret polymer properties.	An, E	1,2,3
CO-5	Apply knowledge of inorganic polymers to solve real-world industrial problems.	R, Ap	1,2,5
CO-6	Equip students with the knowledge and practical skills necessary for the analysis and characterization of various chemical substances	Ap, P	1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INDUSTRIAL CHEMISTRY- V

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	C	L	
2	CO-2	1,3	U	C	L	
3	CO-3	1,2,5	U	C	L	
4	CO-4	1,2,3	An, E	P	T	
5	CO-5	1,2,5	R, Ap	C	L/T	
6	CO-6	1,2,3,4,5	Ap, P	C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PS O4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	2	-	-	3	3	-	-	-	-	-	-
CO 2	3	-	2	-	-	3	3	-	-	-	-	-	-
CO 3	3	2	2	-	-	3	3	-	-	-	-	-	-
CO 4	3	2	3	-	-	3	3	-	-	-	-	-	-
CO 5	3	2	-	-	-	3	3	-	-	-	-	-	-
CO 6	3	2	2	3	3	3	3	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓	✓	✓
CO 5				✓
CO 6				

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE308**				
Course Title	**POLYMER CHEMISTRY-V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Basic knowledge about the waste management 2. UK3DSECHE204, UK4DSECHE204, UK5DSECHE308, UK5DSECHE309				
Course Summary	To impart a better knowledge on types of wastes and the ways to collect, segregate and manage it.				

Detailed Syllabus:

Module	Unit	Content POLYMER CHEMISTRY-V	Hrs 60
I	**INTRODUCTION TO WASTE MANAGEMENT**		**9**
	1	Introduction and definition of waste management, classification of waste: solid, liquid, gaseous, properties of waste	3
	2	Importance of scientific waste management, Climate change and waste, major environmental impacts.	2
	3	Zero waste initiatives, zero waste cities and Countries.	1
	4	Circular economy concept, Sustainable materials, bioplastic products, applications, advantages, types, current uses, future scope.	3
II	**DIFFERENT TYPES OF WASTES AND ITS MANAGEMENT**		**9**
	1	Biodegradable waste and non-biodegradable waste management, Biomedical waste management, Biomedical waste management rule 2018.	2
	2	Chemical waste management	1
	3	E-waste management, E-waste recycling process, E-waste management rule 2016, Glass waste management.	2

	4	Metal waste management, types, recycling process, benefits, negatives, risk, metal theft. Solid waste management rules and regulations, KPCB rule 2020, National Green Tribunal.	4
III	**LIQUID WASTE MANAGEMENT**		**12**
	1	Sewage and sullage, health aspects of sewage, aim of sewage treatment,	3
	2	Sewage treatment plant and process.	3
	3	Effluent treatment plant, need of effluent treatment plant, design of effluent treatment plant, treatment levels and mechanism.	3
	4	Septage treatment systems, process.	3
IV	**PLASTIC WASTE MANAGEMENT**		**18**
	1	The importance of plastics in daily life, its drawbacks, plastic pollution and consequences.	3
	2	Understanding of plastic waste- classification, sources, collection, segregation, identification and techniques used for its separation.	3
	3	Recycling and its types and stages, advantages of plastic recycling. Additives for improving the quality of recycled products.	2
	4	Exposure to environmental issues associated with plastic waste and guidelines and legislation in India for plastics wastes and recycling.	2
	5	Thermoplastic waste management: 4 R’s approach (reduce, reuse, recycle, recover), Recycling classification - primary, secondary, tertiary, quaternary recycling with examples (mechanical, chemical and thermal processes)	4
	6	Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification,	2
	7	On-site disposal methods, compacting and baling	2
V	**Open Ended Module: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc.**		**12**
	1	Conduct seminars based on the topics: Zero Waste Initiatives: Case Studies of Successful Zero Waste Cities, Circular Economy and Sustainable Materials: Innovations and Challenges, Biomedical Waste Management: Best Practices and Regulatory Compliance, E-Waste Management: Recycling Technologies and Environmental Impacts, Metal Waste Management: Recycling Strategies and Risk Mitigation, Effluent Treatment Plants: Design, Operation, and Environmental Benefits, Plastic Waste Management: Legislation, Challenges, and Future Directions.	
	2	Conduct case study on the topics: Analyze the impact of plastic pollution on marine ecosystems and propose strategies for mitigating plastic waste in coastal regions, Zero waste city or country and evaluate the key factors contributing to its success in waste management. Compare and contrast the approaches to sewage treatment and effluent treatment, highlighting their respective advantages and limitations.	
	3	Give the students assignments related to topics: Investigate the challenges and opportunities in implementing the 4 R's approach (reduce, reuse, recycle, recover) for thermoplastic waste management in urban areas, Evaluate the	

		effectiveness of existing legislation and regulations in India for plastic waste management and recycling, identifying areas for improvement.	
	4	Conduct discussion forums which include the topics: The Role of Public Awareness and Education in Promoting Sustainable Waste Management Practices, Addressing Social Equity and Environmental Justice in Waste Management Policies, Technological Innovations for Advanced Recycling and Resource Recovery, Collaborative Strategies for Multisectoral Waste Management Partnerships, Balancing Economic Growth with Environmental Sustainability in Waste Management Decision-Making.	
	5	Conduct an open book exam based on the topic: Discuss the concept of circular economy and its relevance to sustainable waste management practices, with a focus on the role of recycling and resource recovery in closing material loops. **(Or any other related activities introduced by the teacher)**	

References

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2. Ranjith K. Dani and Tanvi Arora, *Waste Management and Sustainable Development*, CRC Press Publishers, 2019.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the classification, properties and importance of scientific waste management, Climate change and waste, major environmental impacts., applications, advantages, types, current uses, future scope.	R, U	PSO-1,2
CO-2	To understand the different types of waste management like Biodegradable waste and non-biodegradable waste management, Biomedical waste management, Chemical waste management, E-waste management, Metal waste management, Solid waste management	U	PSO-1
CO-3	Explain the importance of plastics in daily life, its drawbacks, plastic pollution and consequences., Explain Recycling and its types and stages, advantages of plastic recycling. Additives for improving the quality of recycled products.	R, An	PSO-1,3
CO-4	Exposure to environmental issues associated with plastic waste and guidelines and legislation in India for plastics wastes and recycling.	U	PSO-1,2
CO-5	Discuss sewage and sullage, health aspects of sewage, aim of sewage treatment.	U	PSO-1,2

R-Remember, U-Understand, Ap-Apply, An-Analyze, E-Evaluate, C-Creat

Name of the Course: POLYMER CHEMISTRY V

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) / Tutorial (T)	Practical (P)
1	CO-1	7/1,2	R, U	F, C	L	
2	CO-2	1/1	U	F	L	
3	CO-3	1/1,3	R, An	M	L	
4	CO-4	5/1,2	U	C	L	
5	CO-5	2/1,2	U	P	L/T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	2	-	-	-	-	-	-	-	-	-	2	-
CO 2	3	-	-	-	-	2	-	-	-	-	-	-	-
CO 3	3	-	2	-	-	3	-	-	-	-	-	-	-
CO 4	2	1	-	-	-	-	-	-	-	2	-	-	-
CO 5	2	2	-	-	-	-	3	-	-	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓	✓	✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE309**				
Course Title	**POLYMER CHEMISTRY-VI**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2	5
Pre-requisites	1. Basic knowledge regarding various polymers and their mechanism 2. UK3DSECHE204, UK4DSECHE204, UK5DSECHE308, UK5DSECHE309, UK6DSECHE308				
Course Summary	This elective course aims to provide students with a comprehensive understanding of advanced polymeric materials, including their classifications, synthesis methods, properties, and applications. Students will gain insight into the principles underlying the development and utilization of polymer, enabling them to apply this knowledge in various industrial sectors.				

Detailed Syllabus:

Module	Unit	Content **POLYMER CHEMISTRY-VI**	Hrs 75
I	**POLYMER COMPOSITES**		**9**
	1.1	Introduction, definition, classification-particulate, fiber (short & long), laminates	2
	1.2	Nanocomposites & biocomposites	2
	1.3	Role of fiber and matrix in improving composite properties	2
	1.4	Reinforcing techniques such as hand layup technique, filament winding technique, spray-up technique, and pultrusion	3
II	**POLYMER BLENDS AND ALLOYS**		**9**
	2.1	Classification of polymer blends and alloys, principle of polymer compatibility, Miscibility effect of molecular structure on polymer-polymer interaction	2
	2.2	Thermodynamics of polymer-polymer mixing, Blend morphology & characterization	2
	2.3	Techniques for determination of polymer, polymer miscibility	2

	2.4	Preparation and manufacture of polymer blends, characterization of blends and applications	3
III	**POLYMER NANOCOMPOSITES AND NANO FILLERS**		**9**
	3.1	Composite material, Mechanical properties of Nano composite material: stress – strain relationship, toughness, strength, plasticity	2
	3.2	Synthetic methods for various nanocomposite materials: sputtering, mechanical alloying, sol-gel synthesis, thermal spray synthesis	3
	3.3	Ceramic-Metal Nanocomposites, Ceramic based nanoporous composite, Metal matrix nanocomposites	2
	3.4	Polymer-based nanocomposites Carbon nanotube-based nanocomposites	1
	3.5	Natural nanobiocomposites and Biomimetic nanocomposites	1
IV	**BIO HYBRID POLYMERIC MATERIALS, NEED ANLYSIS AND NOVEL PRODUCT DEVELOPMENT**		**18**
	4.1	Introduction to Biohybrid Polymeric Materials, biomolecule-polymer interactions	2
	4.2	Fabrication techniques-Micro- and nanofabrication techniques	2
	4.3	Design of biofunctional materials for various applications such as drug delivery, tissue engineering, biosensing, and biocatalysis	2
	4.4	Market study – developing of entrepreneurship culture, marketing of the products	4
	4.5	Improving skills – leadership - product diversification – profit concept	2
	4.6	Financial support from various agencies – setting up of industry	2
	4.7	Government regulations- project report- various financial supporting schemes	4
V	**POLYMER ANALYSIS AND PREPARATION**		**30**
	1	Identify everyday plastics by their physical properties	
	2	Determination of density of polymers	
	3	Determination of viscosity average molecular weight of polymer (PVA, Chitosan etc)	
	4	Ash content analysis of plastics	
	5	Effect of liquid on rubber	
	6	Water Absorption test of polymers	
	7	Determine the glass and filler content	
	8	Film preparation using plastic (PVDF, PVA, etc) and biopolymers (Chitosan, etc)	
	9	Preparation of conducting polymer (Polyaniline, Polyphenylene vinylene, Polypyrrole)	
	10	Preparation of thermal conductivity test specimen polymer preparation using polyester resin, epoxy resin, PMMA, Acrylonitrile	

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18. William D. Bygrave, Jeffry A. Timmons Financing Entrepreneurship, Pearson Education,2010.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**

CO-1	Student learn on polymer composites, laminates, nanocomposites, and biocomposites. Role of fibre and matrix in improving composite properties and reinforcing techniques	U	PSO-1
CO-2	Student should understand polymer blend,s preparation and manufacture, characterization of blends and applications, miscibility effect , Techniques for determination of polymer miscibility, and thermodynamics of polymer-polymer mixing, Blend morphology & characterization	U, An	PSO-1,2
CO-3	Student should understand the concept, classification of composite materials and the mechanical properties, synthetic methods for various nanocomposite	U	PSO-1
CO-4	Students learn on biohybrid polymeric materials, its characterization techniques and Micro- and nanofabrication techniques. Students identifies the design of biofunctional materials for various applications	U, An, E	PSO-1,3
CO-5	Student can Conduct market studies and develop an entrepreneurial mindset by understanding marketing strategies, leadership skills, and the concept of product diversification for the rubber industry. Explore financial support options and government regulations for setting up rubber manufacturing ventures	An	PSO- 1,2,3
CO-6	Develop an understanding of various properties of polymers through their experimental determination	Ap	PSO-4

R-Remember, U-Understand, Ap-Apply, An-Analyze, E-Evaluate, C-Create

Name of the Course: POLYMER CHEMISTRY VI

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1/1	U	F, C	L	
2	CO-2	2/1,2	U, An	C	L	
3	CO-3	1/1	U	C	L	
4	CO-4	4/5	U, An	F, C	L	

5	CO-5	1/ 1,2	An	C	L	
6	CO-6	2/4	Ap	P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	3	2	-	-	3		2	-	-	-	-	-	-
CO 3	2	-	-	-	-	3	-	-	-	-	-	-	-
CO 4	3	-	2	-	-	-	-	-	2	-	-	-	-
CO 5	2	2	-	-	-	2	-	-	-	-	-	-	-
CO6	-	-	-	3	-	-	3	-	-	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE310**				
Course Title	**FORENSIC CHEMISTRY - V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Fundamental knowledge on tools and Characterization techniques involved in the Forensic Science 2. Applications of different instruments in Forensic Science 3. UK3DSECHE205, UK4DSECHE205, UK5DSECHE310, UK5DSECHE311				
Course Summary	Introduction of Analytical Chemistry, Sampling and Separation Techniques, Safety in a Chemical Laboratory				

Detailed Syllabus:

Module	Unit	Content **ANALYTICAL TECHNIQUES IN FORENSIC SCIENCE-I**	Hrs 60
I	**SAFETY IN A CHEMICAL LABORATORY**		**12**
	1.1	Common hazards and risks in the laboratory- Personal Safety -personal protective equipment (PPE, coat, glove, goggle, headcap, mask etc)- engineering controls (fume hoods, ventilation systems)	2
	1.2	Emergency equipment and procedures (eyewash stations, fire extinguishers)-Classification of chemicals (flammable, corrosive, toxic, etc.	2
	1.3	Chemical handling and storage guidelines- Safety data sheets (SDS) and chemical labelling- Chemical Spills and Emergencies- Procedures for responding to chemical spills- Emergency shutdown procedures	3
	1.4	Glassware Safety- Proper handling and cleaning of glassware- Prevention of glassware-related accidents Inspection and maintenance of glassware	2
	1.5	Instrumentation Safety- Safety considerations for common laboratory instruments (balances, centrifuges, spectrophotometers, etc.)-Operating procedures and precautions-Maintenance and calibration requirements	3

II	**INTRODUCTION TO ANALYTICAL AND SEPARATION TECHNIQUES**		**12**
	2.1	Systematic and random errors, Source of errors-distribution of experimental results, statistical treatment- standard deviation, variance, confidence limits, application of statistics to data treatment and evaluation	2
	2.2	student-t and f tests, detection of gross errors, rejection of a result-Q test, estimation of detection limits	1
	2.3	Least square method, correlation coefficient and its determination. Hypothesis testing using statistical analysis. Use of spread sheets for plotting calibration curves, quality assurance and control charts	2
	2.4	Basic and advanced concepts of extraction techniques. Working principles and instrumentation for extraction techniques. Distribution ratio and completeness of multiple extractions, types of extraction procedures	2
	2.5	Liquid-Liquid extraction (LLE): Introduction, theory, distribution coefficient, selection of solvents, types of solvent extractions, problems and remedies of LLE process,	3
	2.6	Solid Phase Extraction (SPE): Introduction, Types of SPE media, SPE apparatus, method for SPE operation, solvent selection, factors affecting SPE- Principle of centrifugation, the Swedberg equation, types of centrifuges and rotors-Separation by centrifugation.	2
III	**SAMPLING TECHNIQUES AND CHEMICAL DETECTION METHODS**		**12**
	3.1	Basis and procedure of sampling, sampling statistics, sampling, and physical state, crushing and grinding, gross sampling, size of the gross sample, sampling liquids, gas and solids (Tablets, powders, metals and alloys)	2
	3.2	Statistics in sampling-Preparation of a laboratory sample, Decomposition and dissolution, source of error, reagents for decomposition and dissolution like HCl, H2SO4, HNO3, HClO4, HF	2
	3.3	Microwave decompositions- Elimination of interference from samples-separation by precipitation.	2
	3.4	Overview of forensic science and its role in criminal investigations-Importance of chemical detection methods in crime scene analysis	2
	3.5	Field detection methods in forensic science- Detection of biological fluids like blood, saliva, Urine, semen, faecal matter.	2
	3.6	Field detection of narcotic drugs, psychotropic substances, alcohol, explosives and other contrabands. -Detection of Gun Shot Residue (GSR).	2
IV	**CHROMATOGRAPHIC TECHNIQUES**		**12**
	4.1	Fundamentals of chromatographic separation- Components of a chromatographic system Types of chromatography and their applications-Classification, migration rates of solutes, important relationships	2

	4.2	solid-Gas, liquid chromatography- Adsorption and Partition chromatography, Paper, TLC, LC, HPLC GSC and GLC Instrumentation-Basic principles	2
	4.3	Historical background- Importance of TLC in forensic chemistry- Components of a TLC setup- Types of stationary phases and mobile phases Selection of TLC plates and solvents	2
	4.4	Sample preparation techniques- Application of samples onto TLC plates- Developing and visualizing TLC plates- TLC Analysis and Interpretation- Rf Values and Calibration- Calculation and significance of Retention Factor (Rf) values- Factors affecting Rf values	2
	4.5	Calibration of TLC plates- Interpretation of TLC results-identification of compounds based on TLC patterns-Case studies and practical exercises on TLC analysis-Role of TLC in drug identification and screening	2
	4.6	Applications of TLC in toxicological analysis-Analysis of pharmaceuticals and illicit drugs using TLC-Quantitative TLC Principles of quantitative TLC- Densitometry and other quantitative analysis methods- Applications in forensic quantisation	2
V	**OPEN ENDED MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**12**
		1. Hands on training in different instrumentations available in the lab 2. Visit to R & D labs 3. Preparation of different samples for practical 4. Prepare and display the safety posters in the laboratories	

Reference

1. T. Attwood and P. Smith. *Introduction to Bioinformatics*, USA: Pearson Education, 2007.
2. K. Wilson and J. Walker, *Principles and Techniques of Biochemistry and Molecular Biology*, 7th ed. New York: Cambridge University Press, 2010.
3. W. Taylor and D. Higgins. *Bioinformatics: Sequence, Structure and Databanks: A Practical Approach*, Oxford, 2000.
4. E. Stahl (1969) *Thin Layer Chromatography: A Laboratory Handbook*.
5. D. Halder, M. K. Purkait, P. Duarah, *Advances in extraction and Applications of bioactive phytochemicals*, Academic Press Inc, UK, 2023
6. D. Panhekar, T. P. Sawant, D. P. Gogle, *Phytochemicals-Extraction, Separation & Analysis Techniques*, Globel Education Limited, First Edition, 2019
7. T. J. Quintin, *Chromatography: Types, Techniques and methods*, Nova Publication, 2010
8. A. Thakur, P. Thakur, S. M. P. Khurana, *Synthesis and Applications of Nanoparticles*, Springer, 2022.

Course Outcomes

SI No	Course Outcome: Upon completion of this course the student will be able to	Cognitive Level	PSO
CO-1	Outline lab safety rules and precautions to be taken care in handling the chemicals and Glassware	R	4
CO-2	Identify the different analytical and separation techniques in chemical laboratories	An	1,2
CO-3	Choose different sampling techniques and chemical methods in material preservation	Ap	3,5
CO-4	Explain the role of chromatographic techniques in Forensic Science	U	2,5
CO-5	Demonstrate the safety measurements and separation techniques in the lab	U	3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FORENSIC CHEMISTRY - V

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	4	R	C	L	
2	CO-2	1, 2	An	F, C	L	
3	CO-3	3, 5	Ap	F, C, P	L	
4	CO-4	2, 5	U	F, C, P	L	
5	CO-5	3, 5	U	F, C, P, M	L/T	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	-	-	-	3	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	2	-	-	-	-	-	-	-
CO 3	-	-	3	-	2	-	2	-	-	-	-	-	-
CO 4	-	2	-	-	2	-	-	-	-	-	-	-	3

CO 5	-	-	3	-	2	-	-	-	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE311**				
Course Title	**FORENSIC CHEMISTRY VI**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Safety rules in laboratories and also in handling different chemicals and samples 2. Knowledge in Analytical and separation Techniques 3. UK3DSECHE205, UK4DSECHE205, UK5DSECHE310, UK5DSECHE311, UK6DSECHE310				
Course Summary	Analysis of Fingerprints and Palm Prints, Foot, Footwear, Tyre impressions, Lip Prints, Ear Prints and Their Significance and Biometrics				

Detailed Syllabus:

Module	Unit	Content **IMPRESSIONS IN FORENSIC SCIENCE**	Hrs 45
I	**FINGERPRINTS AND PALM PRINTS**		**12**
	1.1	History and development of Dermatoglyphics, formation of ridges, pattern types, pattern area.	1
	1.2	Classification of fingerprints- Henry's system of classification, single-digit classification, Extension of Henry's classification, filing, searching and fingerprint bureau	2
	1.3	Composition of sweat, development of chance, latent, visible and plastic prints.	1
	1.4	Conventional methods of development of latent prints- fluorescent methods, magnetic powder method, fuming method, chemical method etc	1
	1.5	Application of laser and other radiations to develop latent fingerprints, metal deposition method and development of latent prints on skin	2
	1.6	Taking of fingerprints from living and dead person, preserving and lifting of fingerprints, photography of fingerprints	2

	1.7	Ridge counting and ridge tracing, class and individual characteristics, various types of ridge characteristics.	1
	1.8	Comparison of palm prints on the basis of individual ridge characteristics. Automated Fingerprint Identification System (AFIS). Modern methodologies in fingerprinting	2
II	**BIOMETRICS AND DNA FINGERPRINTING**		**15**
	2.1	Biometric evidences such as finger impressions, retina, iris pattern, voice, gait pattern, face recognition, 3D face recognition	2
	2.2	automatic forensic dental identification, hand vascular pattern technology, Multibiometric systems, Recent developments, biometric databases.	2
	2.3	Chemistry of DNA Fingerprinting Double helical structure of DNA, alternate forms of DNA double helix, denaturation and renaturation of DNA, Chemical nature of DNA and RNA	3
	2.4	Nature and structure of human genome and its diversity.mt-DNA, Y-Chromosomes and the peopling, migration, of modern humans, Concept of gene – Conventional and modern views	2
	2.5	Concept of sequence variation - VNTRs, STRs, Mini STRs, SNPs. Detection techniques –PCR amplification and sequencing using capillary electrophoresis. DNA markers (VNTRs, Stars, SNPs, Y-STRs, mt DNA)- their importance and detection	2
	2.6	DNA extraction, it's qualitative and quantitative assessment, Polymerase chain reaction (PCR), Generation and assessment of DNA profiles.	2
	2.7	Forensic DNA profiling and its application in criminal and civil investigations-Application like disputed paternity cases, missing person identity, population genetics- legal admissibility of DNA evidence	2
III	**IMPRESSIONS, PRINTS AND THEIR SIGNIFICANCE**		**9**
	3.1	Importance, Gait pattern, Casting of footprints in different medium, electrostatic lifting of latent footprints	2
	3.2	Taking of control samples. Collection, tracing, lifting, casting of impressions,	1
	3.3	Enhancement of footwear impressions, analysis and comparison of foot impressions, moulds, identification characteristics	2
	3.4	Nature, location, collection and evaluation of lip prints	1
	3.5	Forensic Significance, photography, location, collection and evaluation, taking of control samples of footprints, lip prints and Ear prints for comparison. Modern techniques and developments	3
IV	**FORENSIC DOCUMENTS**		**9**
	4.1	Document in General: Importance, Classification & Preliminary Examination-Forgery: Definition, Types, Characteristics and their Detection-Disguised Writing and Anonymous Letters	2

	4.2	Definition-Alteration in the Document: Examination of Erasures, Additions, Overwriting and Obliteration- Decipherment of Secret Writing, Indented and Invisible Writing-Charred Documents	2
	4.3	Examination of Counterfeit Currency Notes, Passport, Security Documents, Credit Card, Visa, Seal and other Mechanical Impressions.	2
	4.4	Age of Document: Absolute/Relative Age, Determination of Age of Documents by Examination of Printed Matter, Types Script Writing, Signatures, Paper and Ink. - Physical and Chemical methods in document examination	3
V	**PRACTICALS:**		**30**
		1. Demonstration of different separation techniques 2. Distillation 3. Paper chromatography 4. Column chromatography 5. TLC	

Reference

1. Bridges, B.C; *Criminal Investigation, Practical Fingerprinting, Thumb Impression, Handwriting expert Testimony, Opinion Evidence*., Univ. Book Agency, Allhabad,2000
2. Mehta, M.K; *Indentification of Thumb impression & cross examination of Fingerprints*, N.M. Tripathi Pub. Bombay, 1980.
3. Chatterjee, S.K; *Speculation in Fingerprint Identification*, Jantralekha printing Works, Kolkata, 1981.
4. Cowger James F; *Friction Ridge Skin- Comparison &Identification of Fingerprints*, CRC Press, NY, 1993
5. Cossidy, M.J; *Footwear Identification*, Royal Canadian, Mounted Police, 1980.
6. Iannavelli, A.V; *Ear Identification, Forensic Identification Series*, Paramount,1989.
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8. Jain, A.K., Flynn, P.& Ross A.A., *Handbook of Biometrics*, Springer, New York 2008
9. Lukasz Komsta, Monika Waksmundzka-Hajnos, Joseph Sherma, *Thin Layer Chromatography in Drug Analysis*, CRC Press, London, 2010
10. Arian van Asten, *Chemical Analysis for Forensic Evidence*, Elsevier Publishers 2020
11. Max M. Houck, *Materials Analysis in Forensic Science*, Elsevier Publishers, 2016
12. Katherine M. Koppenhaver, *Forensic Document Examination: Principles and Practice*, Humana Press, 2007.
13. Miriam Angel, et al., *Forensic Document Examination in the 21st Century*, CRC Press.
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15. Butler, J; *Advanced Topics in Forensic DNA Typing: Methodology*, 1st Ed., Academic Press, London, 2009.
16. Spencer, C; *Genetic testimony: a guide to forensic DNA profiling*, Pearson, New Delhi, 2004.

Course Outcomes

SI No	Course Outcome: Upon completion of this course the student will be able to	Cognitive Level	PSO
CO-1	Examine the Fingerprints, Palm Prints and all other impressions in Forensic Science	Ap	3,5
CO-2	Recognize the importance of Biometrics and DNA in crime management	R	3
CO-3	Demonstrate the need of Impressions, Prints and their Significance in crime investigation	U	3,4
CO-4	Detect the forensic documents in forensic science	An	5
CO-5	Assess the different separation techniques, impressions and prints in crime report	E	3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: FORENSIC CHEMISTRY VI

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	3,5	Ap	C	L	
2	CO-2	3	R	F, C	L	
3	CO-3	3,4	U	F, C, P	L	
4	CO-4	5	An	F, C, P	L	
5	CO-5	3,5	E	F, C, P, M	L/T	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	-	-	3	-	2	2		-	-	-	-	-	-
CO 2	-	-	3	-	-	2		-	-	-	-	-	-
CO 3	-	-	3	2	-		2	-	-	-	-	-	-
CO 4	-	-	-	-	2	-	-	-	-	-	-	-	3
CO 5	-	-	3	-	2	-	-	-	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE312**				
Course Title	**CHEMISTRY OF NANOMATERIALS-V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Essential basic knowledge about different spectroscopic methods. 2. Elementary knowledge in the basic principles of quantum mechanics, quantum confinement effect, application of Schrodinger wave equation to simple solvable systems 3. UK3DSECHE206, UK4DSECHE206, UK5DSECHE312, UK5DSECHE313				
Course Summary	The principal objective of this course is to provide necessary and sufficient knowledge in the basic aspects of characterization methods of nanomaterials. This course aims to provide pertinent information related characterization methods which are necessary to explore size dependent properties of the nanomaterials. The basic theory and applications of prominent nanomaterial characterization methods are included in this course				

Detailed Syllabus:

Module	Unit	Course Description **CHEMISTRY OF NANOMATERIALS-V**	Hrs 60
I	**ELECTRON PROBE CHARACTERIZATION METHODS**		**9**
	1.1	Significance of nanomaterial characterization, An overview of different methods for the characterization of nanomaterials, Electron Probe Methods, Electron microscopy,	3
	1.2	Interaction of Electron with Samples- secondary electron, back scattered electron, characteristic X-ray, Auger electron etc., Principle of Scanning Electron Microscopy (SEM), Instrumentation, Applications, Field Emission SEM and 3D-SEM (elementary idea only)	3
	1.3	Principle of Transmission electron Microscopy (TEM), Instrumentation, Sample preparation, HR-TEM, Interpretation of TEM data, Selected Area electron Diffraction (SAED) pattern, Applications	3
II	**SCANNING PROBE METHODS**		**9**

	2.1	Different scanning probe characterization methods, Atomic Force Microscopy (AFM): history of AFM, principle, working, Imaging modes in AFM: contact mode, tapping mode and non-contact mode, Interpretation of results,	3
	2.2	Quantum mechanical tunnelling- tunnelling probability with reference to particle in 1D-box problem	2
	2.3	Scanning Tunneling Microscopy (STM): Principle, Tunnelling current, Instrumentation, Working, Imaging methods- constant current and constant height methods	3
	2.4	Applications of AFM and STM, Comparison between AFM and STM	1
III	**SPECTROSCOPIC TECHNIQUES**		**18**
	3.1	General aspects of different photon probe characterization methods, UV-Visible spectroscopy: Principle, Instrumentation-single beam and double beam UV spectrophotometer	3
	3.2	Applications of UV-Visible spectroscopy in nanomaterial characterization: Determination of surface plasmon resonance (SPR), Band-gap determination, monitoring drug delivery and reaction kinetics etc.	3
	3.3	IR Spectroscopy-principle, instrumentation, Applications of IR-spectroscopy in nanomaterial characterization: Determination of capping agents, functional groups characterization of metal oxide nanoparticles, conjugation with other molecules etc.	3
	3.4	Photoluminescence: Fluorescence, Phosphorescence, Fluorescence life time, Photoluminescence Spectroscopy (PL): Principle, Instrumentation, Applications- monitoring reaction kinetics, fluorescence sensing, static and dynamic quenching	3
	3.5	Dynamic Light Scattering (DLS): Principle, Stokes-Einstein equation, Instrumentation, Applications- determination of hydrodynamic size, particle size distribution	3
	3.5	Raman Spectroscopy: Principle, Applications in nanomaterial characterization, Surface Enhanced Raman Spectroscopy (SERS): Principle and Applications (elementary idea Only)	3
IV	**CHARACTERIZATION METHODS BASED ON X-RAY**		**9**
	4.1	Energy dispersive X-ray Spectroscopy (EDAX): Characteristic X-ray generation, representation of characteristic X-ray, Instrumentation of EDAX, interpretation of EDAX spectrum, Applications	3
	4.2	X-ray diffraction, Types of XRD: Powder XRD, Single Crystal XRD, Thin film XRD, Instrumentation, PXRD Pattern- interpretation of results, crystalline and amorphous solids, Scherrer Equation, Applications	3
	4.3	X-ray Fluorescence Spectroscopy (XRF): Principle, Instrumentation, Applications in nanomaterial characterization	3
V	**OPEN END MODULE: Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc**		**15**
		1. Discuss the significance of nanomaterial characterization and compare different methods for the characterization of nanomaterials. 2. Conduct a seminar on Applications of Electron Microscopy in Nanomaterial Research.	

		3. Describe the interaction of electrons with samples in electron microscopy, including secondary electron emission and characteristic X-ray production. 4. Compare and contrast different scanning probe characterization methods, focusing on atomic force microscopy (AFM) and scanning tunneling microscopy (STM). 5. Discuss the Applications of Scanning Probe Methods in Nanotechnology. 6. Discuss on the Future Directions in Scanning Probe Methods for Nanoscale Imaging and Manipulation 7. Discuss on the Recent Developments and practical applications in UV-Visible and IR Spectroscopy Techniques. 8. Discuss the role of UV-Visible spectroscopy in determining surface plasmon resonance (SPR) and band-gap of nanomaterials. 9. Analyze DLS data from a set of nanoparticles and determine their hydrodynamic size and particle size distribution. Discuss the implications of the results on the properties and applications of the nanoparticles. 10. Investigate a recent research paper or application note showcasing the use of Raman spectroscopy in nanomaterial characterization. Summarize the findings and evaluate the effectiveness of Raman spectroscopy in the given context. 11. Engage in a discussion about recent advancements and future directions in photoluminescence spectroscopy, including novel applications and technological innovations. 12. Analyze X-ray diffraction patterns of different nanomaterial samples, identify crystal structures, and calculate grain sizes using the Scherrer equation.	

References:

1. Hornyak, G. L., Tibbals, H. F., Dutta, J and Moore, J. J. (2008), *Introduction to Nanoscience and Nanotechnology.* CRC Press.
2. Pradeep, T. (2007), NANO*: The Essentials: Understanding Nanoscience and Nanotechnology*. McGraw Hill.
3. Imalka Munaweera, M.L and Madhusha, C. (2023), *Characterization Techniques for Nanomaterials*. CRC Press.
4. Thomas, S., Kumar, R., Thomas, R. and Zachariah, A.K. (2017), *Microscopy Methods in Nanomaterials Characterization*. Elsevier Science.
5. Williams, D. B. and Carter, C.B. (2013), *Transmission Electron Microscopy: A Textbook for Materials Science*. Springer
6. Tantra, R. (2016). *Nanomaterial Characterization: An Introduction*. John Wiley and sons
7. Neddermeyer, H. (2012). *Scanning Tunneling Microscopy*. Springer

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9. Pavia, D.L., Gary M. Lampman, G.M., Kriz, G.S and Vijaan, I.R. (1997) *Spectroscopy*. CBS Publishers and Distributors
10. Lee, M. (2017). *X-Ray Diffraction for Materials Research: From Fundamentals to Applications*. Apple Academic Press
11. West, A. R. (2022). *Solid State Chemistry and its Applications.* Joh Wiley and Sons

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Gain a comprehensive understanding of electron probe methods, including electron microscopy principles, and their applications in nanomaterial characterization	U	1,3
CO-2	Develop proficiency in different scanning probe methods, particularly Atomic Force Microscopy and Scanning Tunneling Microscopy, including principles, imaging modes, interpretation of results, and their applications in nanotechnology	Ap	1,3
CO-3	Apply UV-Visible spectroscopy principles and instrumentation for characterizing nanomaterials, understand the principles and applications of IR spectroscopy in nanomaterial characterization	U, Ap	1,2,3
CO-4	Understand photoluminescence spectroscopy principles, instrumentation, and various applications, Gain proficiency in dynamic light scattering principles, the Stokes-Einstein equation, and applications in determining particle size distribution	U, Ap	1,2,3,4
CO-5	Develop proficiency in Raman spectroscopy principles, including instrumentation and applications in nanomaterial characterization. Gain an elementary understanding of Surface Enhanced Raman Spectroscopy principles and applications	Ap	1,3,4
CO-6	Master the principles and applications of X-ray-based characterization methods, including Energy Dispersive X-ray Spectroscopy for elemental analysis, X-ray diffraction for crystallographic studies, and X-ray	Ap, An	1,2,3

	Fluorescence Spectroscopy for material composition analysis		
CO-7	Integrate knowledge of various characterization techniques to effectively analyse and characterize nanomaterials, demonstrating interdisciplinary skills in nanoscience research	An, E	1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY OF NANOMATERIALS-V

Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,3	U	C	T	
2	CO-2	1,3	Ap	P	T	
3	CO-3	1,2,3	U, Ap	C, P	T	
4	CO-4	1,2,3,4	U, Ap	C, P	T	
5	CO-5	1,3,4	Ap	P	T	
6	CO-6	1,2,3,5	Ap, An	C, P	T	
7	CO-7	1,2,3,5	An, E	C, M	T	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	3	-	-	2	-	-	-	-	-	1	-
CO 2	2	-	3	-	-	3	3	-	-	-	-	2	-
CO 3	3	2	3	-	-	2	2	-	-	-	-	3	-
CO 4	3	3	3	1	-	3	3	-	-	-	-	3	-
CO 5	3	-	3	2	-	3	2	-	-	-	-	3	-
CO 6	2	2	2	-	2	2	2	-	-	-	-	3	-
CO7	2	2	2	-	3	2	1	-	-	-	-	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4	✓	✓	✓	✓
CO 5	✓			✓
CO 6	✓			✓
CO 7	✓			

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE313**				
Course Title	**CHEMISTRY OF NANOMATERIALS-VI**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5 hours
Pre-requisites	1. Elementary idea about the size properties of nanomaterials 2. Elementary knowledge in the basic principles of quantum mechanics, quantum confinement effect. 3. Knowledge about the properties and applications of metal nanoparticles 4. UK3DSECHE206, UK4DSECHE206, UK5DSECHE312, UK5DSECHE313, UK6DSECHE312				
Course Summary	The principal objective of this course is to provide necessary and sufficient understanding of different kind of nanomaterials such as metal nanoclusters, metal organic frameworks, alloy nanoparticles and varieties of polymer-based nanomaterials. This course is also intended to provide an awareness into the notable features of above-mentioned materials and their applications in diverse fields.				

Detailed Syllabus:

Module	Unit	Content **CHEMISTRY OF NANOMATERIALS-VI**	Hrs 75
I	**METAL NANOCLUSTERS**		**9**
	1.1	Size comparison of metal atoms, metal nanoparticles and metal nanoclusters (MNCs), Existence of discrete energy levels in MNCs, Comparison of MNCs with metal nanoparticles (MNPs) in properties such as surface plasmon resonance (SPR)	3
	1.2	General methods of synthesis, Common capping agents for MNCs-thiols, dendrimers, polymers, proteins, DNA etc. Stability of MNCs, General characterization methods for MNCs, Significance of X-ray photoelectron spectroscopy (XPS) and mass spectrometry (MS) in the characterization of MNCs, Luminescence in MNCs	3
	1.3	Synthesis, physical properties and applications of gold nanoclusters (Au NC) and silver nanoclusters (Ag NC), Bimetallic Nanoclusters	3

II	**METAL-ORGANIC FRAMEWORKS**		**9**
	2.1	Metal-Organic Frameworks (MOFs), Primary building units (PBUs), Secondary building units (SBUs), Classification of MOFs, Nomenclature	3
	2.2	Synthesis of MOFs- solvothermal, electrochemical, sonochemical, mechanochemical and microwave assisted methods, Charecterization of MOFs by various methods- importance of nitrogen sorption analysis	3
	2.3	Major Applications of MOFs- gas storage and separation, catalysis, drug delivery, sensing and detection, energy storage and conversion, MOF Nanoparticles and their features	3
III	**ALLOY NANOPARTICLES**		**9**
	3.1	Bimetallic nanoparticles, Synthesis: co-reduction method and successive reduction method, Properties and applications	3
	3.2	Alloy Nanoparticles, Classification: mixed alloyed nanoparticles, sub-cluster segregated alloyed nanoparticles, core-shell alloyed nanoparticles and multiple core-shell alloyed nanoparticles, Physical and chemical methods of synthesis of alloy nanoparticles	3
	3.3	Charecterization of alloy nanoparticles, Physical properties, Applications of alloy nanoparticles: biomedical imaging, drug delivery, catalysis and sensoronic applications	3
IV	**POLYMER BASED NANOMATERIALS**		**18**
	4.1	Classification of polymer-based nanomaterials: natural polymer-based, biosynthesized polymer-based and synthetic polymer-based nanomaterials	3
	4.2	Popular natural polymers: chitosan, starch, cellulose, alginate, chondroitin sulphate and hyaluronic acid	2
	4.3	Polymer Nanoparticles (PNPs), Preparation of PNPs: mini-emulsion polymerization, interfacial polymerization, spray drying method, nanoprecipitation technique and fast evaporation technique, Applications of PNPs	4
	4.4	Nanocomposites, Classification and examples - metal matrix nanocomposites (MMNC), polymer matrix nanocomposites (PMNC) and ceramic matrix nanocomposites (CMNC)	3
	4.5	Synthesis, characterization and applications of PMNCs, Nanofibers, Classification-polymer nanofibers and carbon-based nanofibers	3
	4.6	Synthesis of Nanofibers- Electrospinning, template synthesis, phase separation, self-assembly and nanolithography methods, Applications of nanofibers-tissue engineering, drug delivery, energy storage and catalysis	3
V	**OPEN END PRACTICALS III**		**30**
	A minimum of 5 practical experiments from any two sections must be performed and reported.		
	A. Synthesis of Silica nanoparticles		
	1. Synthesis of silica nanoparticles by Stobber method 2. Reverse microemulsion method for silica nanoparticle synthesis		

	3. Synthesis of meso-porous silica nanoparticles 4. Doped silica nanoparticles via sol-gel method	
	B. Synthesis of hydroxyapatite nanoparticles	
	1. Wet chemical precipitation method of synthesis of hydroxyapatite nanoparticles 2. Hydrothermal synthesis of hydroxyapatite nanoparticles 3. Wet chemical synthesis of metal doped hydroxyapatite nanoparticles	
	C. Synthesis of nanocomposites	
	1. Synthesis of ZnO-Au nanocomposite 2. Synthesis of ZnO-TiO2 nanocomposite 3. Solution mixing synthesis of polymer composite nanoparticles	
	The synthesized nanomaterials can be characterized by methods such as: 1. UV-Visible spectroscopy 2. PXRD 3. SEM 4. EDAX 5. AFM 6. DLS 7. PL spectroscopy 8. Zeta potential measurements 9. IR-Spectroscopy 10. HR-TEM 11. Nitrogen sorption analysis 12. XRF 13. AAS 14. ICP-MS 15. Gouy balance 16. SQUID magnetometer 17. VSM analysis 18. Mass Spectroscopy **Use at least 3 characterization methods, which is suitable for the specific type of nanomaterials**	

References:

1. Hornyak, G. L., Tibbals, H. F., Dutta, J and Moore, J. J. (2008), *Introduction to Nanoscience and Nanotechnology,* CRC Press.
2. Joseph, K., Mathew, M.S., Sabu Thomas, S and Appukuttan, S. (2022), *Luminescent Metal Nanoclusters Synthesis, Characterization, and Applications*, Elsevier Science.
3. Pradeep, T. (2022), *Atomically Precise Metal Nanoclusters*,Elsevier Science
4. Poole, C. P and Owens, F. J. (2003), *Introduction to nanotechnology*,Wiley Inter science.
5. Calvo, F. (2020), *Nanoalloys From Fundamentals to Emergent Applications*, Elsevier Science.
6. Irby, V and Saylor, Y. (2018). *Metal Nanoparticles Properties, Synthesis and Applications,* Nova Science Publishers

7. Njoki, P.N. (2007), *Metal and Alloy Nanoparticles Synthesis, Properties and Applications*, State University of New York
8. Kaskel, S. (2016). *The Chemistry of Metal-Organic Frameworks Synthesis, Characterization, and Applications*, Wiley
9. Sharmin, E and Zafar, F. (2016). *Metal-Organic Frameworks*. Intech Open
10. Narain, R. (2020). *Polymer Science and Nanotechnology, Fundamentals and Applications*,Elsevier Science
11. Haghi, A. K and Zaikov, G. E. (2011). *Nanotechnology and Polymer-based Nanostructures*, Nova Science Publishers
12. Maguire, R. (2013). *Advances in Nanofibers*, Intech Open
13. Ko, F. K and Wan, Y. (2014). *Introduction to Nanofiber Materials*, Cambridge University Press
14. Sharon, M and Sharon, M. (2008), *Carbon Nanofibers Fundamentals and Applications*, Wiley

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Develop a comprehensive understanding of metal nanoclusters and nanoparticles, including their size comparison, discrete energy levels, synthesis methods, and key properties such as surface plasmon resonance	U	1,2
CO-2	Demonstrate proficiency in the synthesis of metal nanoclusters using common capping agents and apply general characterization methods for structural analysis and stability assessment	Ap	1,2
CO-3	Gain specialized knowledge in the synthesis, physical properties, and diverse applications of gold and silver nanoclusters, including luminescence phenomena and the fabrication of bimetallic nanoclusters	An	1,2
CO-4	Acquire an in-depth understanding of metal-organic frameworks, their classification based on primary and secondary building units, and mastery in various synthesis methods and applications	U, E	1,2,3
CO-5	Gain expertise in synthesizing bimetallic nanoparticles using co-reduction and successive reduction methods, classify alloy nanoparticles based on their structures and apply characterization techniques to evaluate their physical properties relevant to specific applications	Ap, An	1,3,5

CO-6	Learn the classification of polymer-based nanomaterials and prepare polymer nanoparticles (PNPs) using advanced techniques and explore applications of PNPs in diverse fields	Ap	1,2,3
CO-7	Understand the synthesis methods of nanofibers using various techniques, explore the classification and applications of nanocomposites with a focus on tissue engineering, drug delivery and catalysis	Ap, E	1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHEMISTRY OF NANOMATERIALS -VI

Credits: 3:0:1 (Lecture:Tutorial: Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2	U	C	L	
2	CO-2	1,2	Ap	P	T	
3	CO-3	1,2	An	C	L	
4	CO-4	1,2,3	U, E	P, C	L	
5	CO-5	1,3,5	Ap, An	P		P
6	CO-6	1,2,3	Ap	P, C	L	
7	CO-7	1,2,3,4,5	Ap, E	P, M		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	-	-	-	2	2	-	-	-	-	-	-
CO 2	3	3	-	-	-	2	3	-	-	-	-	-	-
CO 3	2	2	-	-	-	3	3	-	-	-	-	-	-
CO 4	2	3	2	-	-	3	2	-	-	-	-	3	-
CO 5	3	-	3	-	3	2	3	-	-	-	-	2	-
CO 6	2	3	3	-	-	3	3	-	-	-	-	3	-

CO7	2	3	3	3	2	2	3	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓		✓
CO 5	✓		✓	✓
CO 6	✓			
CO 7	✓			

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE314**				
Course Title	**PHARMACEUTICAL AND MEDICINAL CHEMISTRY-V**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Basic knowledge on co-ordination chemistry and Radioactivity 2. UK3DSECHE207, UK4DSECHE207, UK5DSECHE314, UK5DSECHE315, UK6DSECHE314				
Course Summary	This course provides a comprehensive understanding of chelation therapy, vitamins, prodrugs, respiratory and gastrointestinal drugs, and the use of radioisotopes in medicine, preparing students for careers in pharmacy, pharmaceutical sciences, and healthcare				

Module	Unit	Content **PHARMACEUTICAL AND MEDICINAL CHEMISTRY-V**	Hrs 60
I	**CHELATING AGENTS**		**9**
	1.1	Definition Chelating agent- examples (mono, di and polydentate ligands)	2
	1.2	chelating agent drugs- Chelation of Dimercaprol-application in poisoning of As, Hg, Au, Bi, Sb- Use of $CaNa_2EDTA$, Dimercaptosuccininc acid Adverse effect of Chelating agents	4
	1.3	Uses and adverse effect of - Pencillamine, Desferrioxamine, Deferiprone Deferasirox	3
II	**VITAMINS AND PRODRUGS**		**9**
	1.1	Broad classification of Vitamins- Fat soluble, Water soluble Chemistry, Structure, Source and Deficiency and examples of vitamin supplements currently used: - Vitamin A- role in Visual cycle Vitamin E- Antioxidant Vitamins and its use	3
	1.2	Vitamin B-Thiamine, Riboflavin, Pyridoxine	1
	1.3	Vitamin C and introduction to antioxidant vitamins	1
	1.4	Introduction to Prodrugs: Prodrugs with one example each-Esters as prodrug-N-methylation, Trojan horse approach for carrier proteins	2
	1.5	Prodrug to prolong drug activity-Prodrug masking drug toxicity and side effect - Prodrug to lower solubility in water-Prodrug to improve solubility in water - Prodrug to increase chemical stability-	2

III	**DRUGS FOR RESPIRATORY DISORDER AND GASTRO INTESTINAL TRACT**		**18**
	3.1	Introduction to classification and sub classification of Drugs for cough- Expactorants - antitussives-	1
	3.2	Bromhexine, Ambroxol, Acetylcysteine	2
	3.3	Opiod - Codeine, Ethyl morphine (plant source and adverse effect)	2
	3.4	Nonopiod - Chlophedianol, Noscapine (differentiate between opiod and nonopioid)	2
	3.5	Antihistamine-Fexofenadine and Loratadine- Bronchodilators-Aromatic Chest rub	2
	3.6	Introduction to Gastro Intestinal Drugs-Definition, classification and pharmacological actions dose,	3
	3.7	Indications and contraindications of Anti-ulcer drugs Anti-emetics Laxatives, purgatives, Anti-diarrheal drugs	3
	3.8	Use of Cimetidine, Omeprazole-Antacids-$MgCO_3$, $CaCO_3$, - Ulcer protective drug- Preparation of Bismuth subcitrate (CBS)	3
IV	**RADIOISOTOPES IN MEDICINE**		**9**
	4.1	Introduction to radio activity, Units or radio activity Different Radioactive isotopes	2
	4.2	Properties of commonly used diagnostic and therapeutic radiopharmaceuticals; Tc-99m and its source Production of radionuclides by reactors, cyclotrons and radionuclide generators; Quality assurance and quality control of radiopharmaceuticals	4
	4.3	Radioactive isotopes in medical field-Iodine-123, Yttrium-90, Fluorine-18 and Gallium-67 Definition -Biomarkers (FDG-PET scan use and structure of FDG)	3
V	**OPEN ENDED MODULE: Learning through Discussion, Assignment, Presentation, Quizzes, Open book exams etc**		**12**
	1	Assignment on different chelating agents (e.g., $CaNa_2EDTA$, dimercaprol, dimercaptosuccinic acid) to small groups of students. Each group creates a multimedia presentation explaining the mechanism of action, indications, contraindications, and adverse effects of their assigned chelating agent	
	2	Write a a literature review encompassing diverse incidents of heavy metal poisoning worldwide	
	3	Divide the class into roles representing different vitamins, such as Vitamin A, Vitamin E, etc. And conduct a quiz related to its role in the body, dietary sources, and potential deficiency consequences	
	4	Debate on fast food and natural food creating knowledge among students for understanding healthy food habits	
	5	Conducting test paper to check the basic theory on radioactivity and group discussion on prose and cones of radioactivity	
	6	Group discussion on adverse effect of overuse of drug.	

References:

1. *Essentials of Medical Pharmacology* 8th edition- KD Tripatti
2. *Pharmacology and Pharmacotherapeutics*" by RS Satoskar, SD Bhandarkar, and NS Ainapure.
3. *Basic Nuclear Medicine* by Gopal B. Saha
4. *Textbook of Respiratory Medicine* by RS Kumar
5. *Medicinal Pharmacology* K L Tripathi,8th edition
6. *Medicinal Chemistry* V.K. Ahluwalia and Madhu Chopra
7. *Pharmacology for Medical graduates* Tara V Shanbhag and Smita Shenoy, Elsevier

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Develop a comprehensive understanding of chelation therapy, including the definition and properties of chelating agents, their applications in heavy metal poisoning, and the associated adverse effects. Learn about the therapeutic applications of chelating agents in treating heavy metal poisoning, including lead, mercury, arsenic, gold, and bismuth toxicity.	U, A	PSO-1,3,5
CO-2	Understanding of Broad Classification of Vitamins and Role of Specific Vitamins and the need of taking healthy diet. Students will grasp the concept of prodrugs	U	PSO-1,3,4
CO-3	Differentiate opioid and non-opioid drug and understand the side effects of overdose. Differentiate skill in preparing antacid	C	PSO-1,3,4
CO-4	Appreciate the importance of radioactive substance in the field of medicine apart from its side effect	U	PSO-1,3,5
CO-5	Promote awareness of the importance of rational drug use, patient education, and healthcare policy interventions to mitigate the risks associated with drug overuse	R	PSO-1,2,3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHARMACEUTICAL AND MEDICINAL CHEMISTRY-V

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,3,5	U, A	F	L	-
2	CO-2	PSO-1,3,4	U	C, P	L/T	-
3	CO-3	PSO-1,3,4	C	F, C	L/T	-
4	CO- 4	PSO-1,3,5	U	C, P	L	-
5	CO- 5	PSO-1,2,3,4	R	C, P	L/T	-

S-F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

T-**Mapping of COs with PSOs and POs:**

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	-	2	-	3	2	-	1	-	-	-	-	-
CO 2	2	-	1	1	-	-	-	-	3	-	-	-	-
CO 3	1	-	3	4	-	-	-	3	-	-	-	-	-
CO 4	1	-	3	-	1	1	-	-	-	-	-	-	-
CO 5	2	2	1	4	-	-	-	-	-	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6DSECHE315**				
Course Title	**PHARMACEUTICAL AND MEDICINAL CHEMISTRY-VI**				
Type of Course	**DSE**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Knowledge on colloids and its classification 2. Basic knowledge on Electrolytes 3. UK3DSECHE207, UK4DSECHE207, UK5DSECHE314, UK5DSECHE315, UK6DSECHE314, UK6DSECHE315				
Course Summary	The course provides a comprehensive understanding of drug discovery, formulation, and practical laboratory skills essential for students pursuing careers in pharmaceutical sciences. It combines theoretical knowledge with hands-on experience to prepare students for real-world applications in the field.				

Detailed Syllabus:

Module	Unit	Content **PHARMACEUTICAL AND MEDICINAL CHEMISTRY-VI**	Hrs 75
I	**CONCEPT TO MARKET: STAGES AND PHASES OF DRUG DISCOVERY PROCESS**		**18**
	1.1	Target identification (enzyme, Receptors, Protein, Nucleic acid, Lipids Carbohydrate) Pharmakokinetics (Lipinsk's rule of five)	5
	1.2	Identification of Lead (natural /synthetic source) SAR relationship-Computer aided drug design	3
	1.3	Combinatorial synthesis Mix and Split synthesis, Parallel -Advantages of Combinatorial synthesis in drug discovery	4
	1.4	Bio assay in vitro and in vivo) Preclinical and clinical trial Ethical issues (in clinical and preclinical trials)	3
	1.5	Proprietary Name and Generic Name (3 examples - antibiotic, antidepressant, antihypertensive, antihistamine)	3
II	**ELECTROLYTES, BIOMOLECULES AND MINERALS**		**9**
	2.1	Major extra and intracellular electrolytes: Functions of major	4

		physiological ions, Electrolytes used in the replacement therapy: Sodium chloride, Potassium chloride, Calcium gluconate* and Oral Rehydration Salt (ORS), Physiological acid base balance.	
	2.2	Essential minerals, macro and micronutrient and its functions	1
	2.3	Introduction, classification, chemical nature and biological role of carbohydrate, lipids, nucleic acids, amino acids and proteins	4
III	**APPLICATION OF COLLOIDS IN DRUG FORMULATION**		**9**
	3.1	Monophasic liquids: Definitions and preparations of Gargles, Mouthwashes, Throat Pain, Eardrops, Nasal drops, Syrups, Elixirs, Liniments and Lotions.	3
	3.2	Biphasic liquids: Suspensions: Definition, advantages and disadvantages, classifications,	2
	3.3	Emulsions: Definition, classification, emulsifying agent, test for the identification of type of Emulsion,	2
	3.4	Methods of preparation of Emulsion & stability problems and methods to Overcome	2
IV	**DESIGNING OF DRUG BY COMPUTATIONAL TOOLS**		**9**
	4.1	Pub Chem, Drug Bank, Chem spider, Representation of Protein data Bank, PDB ID Drugs: Smile notation, IUPAC name.	2
	4.2	Chemical formula, molecular descriptors, 2D representation, Docking softwares (free software)	2
		Formats: SDF, MOL, MOL2	1
	4.3	Softwares: Building chemical structures with Chem sketch, Chemical descriptors, software's -predicting activities of drug molecules using SAR by computational tools	2
	4.4	Identification of Pharmacophore by free softwares- Analyze the bonding interaction with target- functional group as binding groups, Functional group modifications	2
V	**PRACTICALS III-MEDICINAL AND PHARMACEUTICAL CHEMISTRY**		**30**
	1	Experiments involving laboratory techniques • Simple Distillation (Distillation of Ethanol and water mixture • Steam distillation	
	2	Separation and Purification: • Separation of para nitro benzoic acid and naphthalene by solvent extraction and purification by Column Chromatography • Identification by TLC • Extraction of Beta-carotene in Spinach	
	3	• Isolation of Nicotine from Tobbaco leaves • Isolation of Caffeine from Tea	
	4	• Determination the solubility of drug at room temperature	

		• Determination of stability constant and donor acceptor ratio of PABA-Caffeine complex by solubility method • Determination of Partition co- efficient of benzoic acid in benzene and water • Melting point determination of Benzoic acid and Caffeine • Estimation of Paracetamol by colorimetric estimation	

References

1. GL Patrik, *Medicinal Chemistry* 2nd edition
2. Barry A. Bunin, *Chemoinformatics: Theory, Practice, & Products"*
3. *Pharmaceutical Dosage Forms and Drug Delivery Systems* Howard C. Ansel, Loyd V
4. C.V.S. Subramanyam *Physical Pharmaceutics*
5. Gaurav Jain & Roop K. Khar *Text book of Physical Phramacy*
6. Anees A. Siddique and Seemi Siddique *Natural Products Chemistry Practical Manual*
7. A.I. Vogel, *Text Book of Quantitative Inorganic analysis*

Course outcome

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students acquire, thinking ability and motivation to design a drug molecule	C	PSO-1,3
CO-2	Skill in using various computational tools for drawing the structure of drug and analyse the activity by utilizing computational tools	Ap	PSO-1,3,5
CO3	Building chemical structures using softwares, predicting activities of drug molecules using structure-activity relationships (SAR) by computational tools	An, E	PSO-1,3,2
CO4	Develop skill in doing experiments involving techniques such as simple distillation, steam distillation, solvent extraction, column chromatography, and thin-layer chromatography	R, Ap	PSO-1,32
CO5	The course outcomes aim to equip students with a comprehensive understanding of laboratory techniques, analytical methods, and experimental design principles essential for chemical analysis and	C	PSO-1,3,4

	organic compound characterization.		

U-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: PHARMACEUTICAL AND MEDICINAL CHEMISTRY-VI

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,3	C	F	L	-
2	CO-2	PSO-1,3,5	Ap	C, P	L/T	-
3	CO-3	PSO-1,3,2	An, E	F, C	L/T	-
4	CO- 4	PSO-1,32	R, Ap	C, P	L	-
5	CO- 5	PSO-1,3,4	C	C, P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	-	1	-	-	-	-	-	-	-	1	2	-
CO 2	1	-	1	-	3	-	-	2	-	-	-	2	-
CO 3	2	1	2	-	-	-	-	1	-	-	-	-	-
CO 4	2	3	1	-	-	-	-	1	-	-	-	-	-
CO 5	1	1	3	-	-	2	-	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6SECCHE300**				
Course Title	**CHROMATOGRAPHY**				
Type of Course	**SEC**				
Semester	6				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3
Pre-requisites	1. A foundational knowledge in general chemistry, analytical techniques and a basic understanding of organic chemistry principles.				
Course Summary	The course covers different separation techniques used in chemistry, different types of chromatography, their principles, experimental technique and applications especially in paper, TLC and column chromatography				

Detailed Syllabus:

Module	Unit	Content	Hrs
		CHROMATOGRAPHY	**45**
I		**INTRODUCTION TO SEPARATION TECHNIQUES**	**6**
	1	Fundamentals of separation processes, Equilibrium based - distillation, solvent extraction and evaporation and	1
	2	Rate controlled –sieving, sedimentation, centrifugation, filtration, membrane process, sorption processes	2
	3	Drawbacks of conventional separation processes, Need to advanced separation processes	1
	4	Major application areas of advanced separation processes.	2
II		**INTRODUCTION TO CHROMATOGRAPHY**	**6**
	5	Introduction – principle, theory and application in chemical analysis	2
	6	Classification of different chromatographic methods, different migration, adsorption phenomena, partition, adsorption coefficient	3
	7	Retardation factor, retention time and volume, column capacity.	1
III		**PAPER, THIN LAYER AND COLUMN CHROMATOGRAPHY**	**15**
	8	Paper chromatography: Principle, papers as a chromatographic medium, modified papers, solvent systems, mechanism of paper chromatography, experimental technique, different development methods-ascending, descending, applications.	3
	9	Thin layer chromatography: principle, chromatographic media coating materials, applications, activation of adsorbent, sample development,	4

		solvent systems, development of chromatoplate, types of development, visualization methods, documentation, and applications in the separation.	
	10	Principle of adsorption and partition chromatography.	2
	11	Column chromatography: adsorbents, classification of adsorbents, solvents, forces between adsorbent and solutes, nature of forces between adsorbent and eluents	3
	12	Preparation of column, column efficiency and applications	3
IV	**APPLICATION OF CHROMATOGRAPHY**		**9**
	13	Applications- pharmaceutical, chemical, food industry, forensic science	3
	14	Preparation of TLC plate - separation of a sample mixture (Hands on training)	6
V	**OPEN ENDED MODULE**		**9**
	15	Seminar presentations, group discussions, debates, quizzes etc on the above modules – demonstration and hands on training of different chromatographic techniques in the lab. **(Or any other related activities introduced by the teacher)**	9

REFERENCES

1. D.A. Skoog, D.M. West and F.J. Holler, *Analytical Chemistry: An Introduction*, 5th edition, Saunders college publishing, Philadelphia, 1990.
2. U.N. Dash, *Analytical Chemistry: Theory and Practice,* Sultan Chand and sons Educational Publishers, New Delhi, 1995.
3. R. Gopalan, *Analytical Chemistry*, S. Chand and Co., New Delhi.
4. R.P.W Scott, *Techniques and practice of Chromatography*, Marel Dekker Inc., New York.
5. M.N. Sastri, *Separation methods*, Himalaya Publishing Company, Mumbai.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the different separation technique used in chemistry	U	PSO-1,2,3
CO-2	Discuss the principle and classification of chromatography	U	PSO-1,2,3
CO- 3	Develop paper chromatogram and TLC	Ap	PSO-1,2,3
CO- 4	Demonstrate column chromatography	Ap	PSO-1,2,3
CO-5	Develop skills in handling TLC for separating mixtures	C	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CHROMATOGRAPHY

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	U	F, C	L	-
3	CO- 3	PO-1,2,6 PSO-1,2,3	Ap	P	L/T	-
4	CO- 4	PO-1,2,6 PSO-1,2,3	Ap	P	L/T	-
5	CO-5	PO-1,2,3,6 PSO-1,2,3,4,5	C	M	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	2	-	-	-	-	3	-	-
CO 2	3	3	-	-	-	2	-	-	-	-	3	-	-
CO 3	3	3	3	-	-	2	1	-	-	-	3	-	-
CO 4	3	3	3	-	-	2	1	-	-	-	3	-	-
CO 5	2	3	3	2	2	2	2	1	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3		✓	✓	
CO 4			✓	
CO 5			✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK6SECCHE301**				
Course Title	**COMPUTERS IN CHEMICAL SCIENCE**				
Type of Course	**SEC**				
Semester	**6**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3
Pre-requisites	1. Basic knowledge of general chemistry, organic chemistry, and physical chemistry principles 2. Fundamental knowledge and proficiency in computer science.				
Course Summary	The course covers computers, operating system and application software, e-resources, drawing of chemical structures, chemical databases, molecular visualization tools and file format.				

Detailed Syllabus:

Module	Unit	Content	Hrs
		COMPUTERS IN CHEMICAL SCIENCE	**45**
I	**OVERVIEW OF COMPUTERS**		**6**
	1	History of computers, Features of the modern personal computer and peripherals	2
	2	Computer network and internet. Data information and knowledge Knowledge management – internet as a knowledge repository.	4
II	**WORD PROCESSING AND DATA HANDLING**		**6**
	3	Overview of operating system	2
	4	Major application of software-word processor, excel, power point for MS office and Libre office. Overview of operating system	4
III	**INTRODUCTION TO E-RESOURCES, CHEMICAL DATABASES, MOLECULAR VISUALIZATION TOOLS AND FILE FORMAT**		**15**
	5	Educational softwares – INFLIBNET, NICNET, BRNET, NPTEL	3
	6	VIRTUAL LABS OF MHRD academic services, e-journals.	4
	7	PubChem, ZINC, Cambridge Structural Database (CSD)	3
	8	Molecular visualization tools –Avogadro, Molden, Molekel File format-PDB and CIF.	5
IV	**REPRESENTATION OF CHEMICAL STRUCTURE**		**9**
	9	Structure drawing, collection of chemistry software by RISC, preparation of seminar papers and project using computers.	2

	10	Basics of cheminformatics, applications of cheminformatics, storage & retrieval, visual screening	4
	11	QSAR (Quantitative Structure Activity Relationship) Introduction to molecular modelling, (Elementary idea only)	3
V	**OPEN ENDED MODULE**		**9**
	12	Seminar presentations, group discussions, debates, quizzes, hands on training etc on the above modules **(Or any other related activities introduced by the teacher)**	

REFERENCES

1. R T Mishra, *Teaching of information Technology*.
2. M Ravikumar, *Information Technology for Higher Education*
3. V. Rajaram, *Introduction to Information Technology*, Prentice Hall
4. Barbara Wilson, *Information Technology*, The Basics, Thomas Learning
5. Alexis Leon & Mathews Leon, "*Computers Today*", Leon Vikas
6. Alexis & Mathews Leon, "*Fundamentals and Information Technology*". Leon Vikas ISBN 08125907890.
7. Ramesh Bangia, "*Learning Computer Fundamentals*", Khanna Book Publishers, ISBN 818752252b.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss the various peripheries and network on computers	U	PSO-1,2,3
CO-2	Apply different software to prepare seminar, project etc	Ap	PSO-1,2,3
CO- 3	Use different e- resources to obtain data	U	PSO-1,2,3
CO-4	Draw chemical structures using different software	Ap	PSO-1,2,3
CO- 5	Discuss about Chemical Databases, Molecular visualization tools and File format	U	PSO-1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: COMPUTERS IN CHEMICAL SCIENCE

Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO	CO	PO/ PSO	Cognitive	Knowledge	Lecture (L)/	Practical

No.			Level	Category	Tutorial (T)	(P)
1	CO-1	PO-1,6,7 PSO-1,2,3	U	C	L	-
2	CO-2	PO-1,2,7 PSO-1,2,3	Ap	C, P	L/T	-
3	CO- 3	PO-1,2,3,7 PSO-1,2,3	U	P	L/T	-
4	CO-4	PO-1,2,3,7 PSO-1,2,3	Ap	P	L/T	-
5	CO- 5	PO-1,2,3,7 PSO-1,2,3,5	U	C, P	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	3	-	-	2	-	-	-	-	2	3	-
CO 2	2	2	3	-	-	2	2	-	-	-	-	3	-
CO 3	2	2	3	-	-	2	2	2	-	-	-	3	-
CO 4	2	2	3	-	-	2	3	3	-	-	-	3	-
CO 5	2	3	3	-	3	2	2	2	-	-	-	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2		✓	✓	
CO 3		✓	✓	
CO 4		✓	✓	
CO 5	✓			✓

SEMESTER 7

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK7DSCCHE400**				
Course Title	**ADVANCED INORGANIC CHEMISTRY I**				
Type of Course	**DSC**				
Semester	7				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK1DSCCHE100, UK4DSCCHE200, UK5DSCCHE300, UK5DSCCHE305				
Course Summary	The course delivers solid electrolytes, molecular materials, advanced coordination chemistry, electronic and magnetic spectra of metal complexes, and practical experiments in inorganic estimations and preparations. Students will gain a deep understanding of the interdisciplinary nature of inorganic chemistry, explore emerging research directions, and a deep knowledge on coordination complexes and develop practical skills through hands-on laboratory work, preparing them for the challenges and opportunities in the field.				

Detailed Syllabus:

Module	Unit	Content ADVANCED INORGANIC CHEMISTRY I	Hrs 75
I	FRONTIERS IN INORGANIC CHEMISTRY		9
	1	Introduction to Frontiers in Inorganic Chemistry - Overview of the interdisciplinary nature of inorganic chemistry, Importance of inorganic chemistry in addressing global challenges and advancing technology, Discussion on emerging trends and research directions in the field.	1
	2	Solid Electrolytes: Mixed oxides, cationic, anionic solid electrolytes, mixed ionic-electronic conductors	2
	3	Solid Oxide Fuel Cells (SOFC), Rechargeable battery materials	1
	4	Solid state chemistry of metal nitrides and fluorides, chalcogenides, intercalation chemistry and metal-richphases.	2
	5	Inorganic pigments, Inorganic phosphors.	1
	6	Molecular materials and fullerides, basic idea of molecular materials chemistry like One dimensional metals, Molecular magnets and Inorganic liquid crystals.	2

II	**ADVANCED COORDINATION CHEMISTRY**		**12**
	7	Crystal field theory: Splitting of d orbitals in octahedral, tetragonal, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields.	4
	8	Jahn-Teller theorem, evidence for JT effect, static anddynamic JT effect.	1
	9	Crystal Field Stabilization Energy. Octahedral Site Stabilization Energy. Factors affecting the splitting parameter.	2
	10	Spectrochemical series. Evidence of covalency in Metal- Ligand bond - Ligand field theory.	2
	11	Molecular Orbital Theory. Sigma and pi bonds in complexes. MO diagrams of octahedral and tetrahedral complexes with and without pi bonds.	2
	12	Experimental evidence of pi bond on the stability of sigma bond. Nephelauxetic effect.	1
III.	**ELECTRONIC SPECTRA OF METAL COMPLEXES**		**12**
	13	Electronic spectra of metal complexes-Term symbols of dn system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields.	3
	14	Correlation diagrams for dn and d10-n ions in octahedral and tetrahedral fields (qualitative approach only), d-d transition, selection rules for electronic transition, effect of spin orbit coupling and vibronic coupling.	3
	15	Interpretation of electronic spectra of complexes- Orgel diagrams, Tanabe-Sugano diagrams, calculation of Dq, B and β (Nephelauxetic ratio) values, charge transfer spectra.	3
	16	Spectral properties of lanthanides and actinides.	2
	17	Applications of electronic spectra in the structural studies of complexes	1
IV	**MAGNETIC SPECTRA OF METAL COMPLEXES**		**12**
	18	Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility	2
	19	Temperature dependence of magnetism. Temperature Independent Paramagnetism (TIP). Spin state crossover, Antiferromagnetism - inter and intra molecularinteraction.	2
	20	Thermal population of different energy levels-large and small multiplet widths	2
	21	Spin-only magnetic moment, Orbital contribution to magnetic moment, Anti-ferromagnetism	2
	22	Magnetics properties of lanthanides and actinides. Lanthanide complexes as shift reagents.	2
	23	Application of magnetic measurements in the determination of structure of transition metal complexes.	2
V	**PRACTICALS: INORGANIC ESTIMATIONS & PREAPARATIONS**		**30**
		Any 10 Experiments (minimum one from each section)	
	24	Volumetric estimation using EDTA - Zn, Mg, Ni (backtitration), Hardness of water, Ca (using murexide).	
	25	Determine the hardness of water and the concentration of Ca in water samples using EDTA.	

	26	Volumetric estimation of Fe.	
	27	Colorimetric estimation of Chromium – (Diphenylcarbazide), Iron (thioglycollic acid), Iron (thiocyanate), Manganese (potassium periodate), Nickel (dimethylglyoxime).	
	28	Preparation of metal complexes - Record UV, IR, magnetic susceptibility, TG, DTA and XRD of the complexes prepared (a) Potassium trioxalatochromate (III) (b) Tetraammoniumcopper (II) sulpahte (c) Hexamminecobalt (III) chloride	

References:

1. F.A. Cotton, *Chemical Applications of Group Theory*, Wiley Eastern, 3rd edition, 2009.
2. A. S. Kunju and G. Krishnan, *Group Theory and its Applications in Chemistry*, PHI Learning, 2010.
3. R. L. Carter, *Molecular Symmetry and Group Theory*, John Wiley& Sons, 1998.
4. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, John Wiley and Sons, 6th edition, 1999.
5. J. E. Huheey, *Inorganic Chemistry- Principles of Structure and Reactivity*, Harper Collins College Publishing, 4th edition, 2011.
6. S. F. A. Kettle, *Physical Inorganic Chemistry*, Oxford University Press, 1st edition, 1998.
7. S. Cotton, *Lanthanides and Actinides*, Macmillan, 1991.
8. B. N. Figgins and M. A. Hitchman, *Ligand Field Theory and its Applications*, Wiley-VCH, 2000.
9. A. Syamal and R. L. Datta, *Elements of Magnetochemistry*, Affiliated East- West Press, 1980.
10. N. N. Greenwood and A. Earnshaw, *Chemistry of Elements*, REPP Ltd, 2nd edition, 2005.
11. A. Earnshaw, *Introduction to Magnetochemistry*, Academic Press, 1968.
12. K. F. Purcell and J. C. Kotz, *Inorganic Chemistry*, Saunders, 1977.
13. S. F. A. Kettle, *Physical Inorganic Chemistry*, Oxford University Press, 1st edition, 1998.
14. Shriver and Atkins, *Inorganic Chemistry*, Oxford University Press, 2010.
15. Douglas, D. H. Mc Daniel, J. J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn. John Wiley & Sons, 2006.
16. J. D. Lee, Concise *Inorganic Chemistry*, 5th Edn. Chapman & Hall, 1996.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Emphasizing the interdisciplinary nature of inorganic chemistry and its significance in addressing global challenges and technological advancements.	U, An	PSO-1,2,3

CO-2	Equip with the knowledge and skills to explore emerging research directions and contribute to innovative solutions in the field of inorganic chemistry.	An, Ap	PSO-1,2,3
CO-3	Apply the theories of coordination chemistry, predict the splitting patterns of d orbitals, and analyze the factors influencing the stability and reactivity of metal-ligand bonds.	Ap, E	PSO-1,2
CO-4	Predict and interpret the electronic spectra of lanthanide and actinide complexes, and understand the applications of electronic spectra in their structural studies.	E	PSO-1,2,3
CO-5	Gain knowledge of spin states, to apply magnetic measurements in determining the structure of transition metal complexes.	U, An	PSO-1,2
CO-6	Develop skills in experimental and apply effectively in quantitative and qualitative chemical analysis	An, Ap	PSO-1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ADVANCED INORGANIC CHEMISTRY I

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U, An	F, C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	An, Ap	C, P	L	-
3	CO-3	PO-1,6 PSO-1,2	Ap, E	F, C	L	-
4	CO-4	PO-1,6 PSO-1,2,3	E	C	L	-
5	CO-5	PO-1,6 PSO-1,2	U, An	C	L	-
6	CO-6	PO-1,2,3,6 PSO-1,2,3,5	An, Ap	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	2	-	-	-	-	3	-	-
CO 2	3	3	2	-	-	2	-	-	-	-	3	-	-
CO 3	3	3	-	-	-	2	-	-	-	-	3	-	-
CO 4	3	3	2	-	-	2	-	-	-	-	3	-	-
CO 5	3	3	-	-	-	2	-	-	-	-	3	-	-
CO 6	3	3	2		2	2	2	2	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK7DSCCHE401**				
Course Title	**ADVANCED INORGANIC CHEMISTRY II**				
Type of Course	**DSC**				
Semester	7				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	UK1DSCCHE100, UK4DSCCHE200, UK5DSCCHE300, UK5DSCCHE305				
Course Summary	In the Crystalline State, students will study crystal symmetry, close-packed structures, X-ray diffraction techniques, crystal defects, and various crystalline structures of compounds. In Solid State Chemistry, they will explore electronic structure, conductors, insulators, semiconductors, and properties of inorganic solids, including superconductivity and dielectric properties. The Chemistry of Natural Environmental Processes module will cover atmospheric, hydrospheric, and lithospheric chemistry, and their impact on human health and the environment. Next module delas with Isopoly & Heteropoly Acids, Silicon-Oxygen & Xenon Compounds, and they will participate in an open-ended module, fostering critical thinking and problem-solving skills.				

Detailed Syllabus:

Module	Unit	Content **ADVANCED INORGANIC CHEMISTRY II**	Hrs 60
I	**CRYSTALLINE STATE**		**12**
	1	Crystal symmetry- Introduction to point groups andspace groups. Miller indices. Reciprocal lattice concept.	1
	2	Close packed structures: BCC, FCC and HCP. Voids.Coordination number.	2
	3	X-ray diffraction by crystals: Function of crystals. Transmission grating and reflection grating. Bragg's equation.	2
	4	Diffraction methods: Powder and rotating crystal. Indexing and determination of lattice type and unit cell dimensions of cubic crystals.	1
	5	Crystal defects: Perfect and imperfect crystals. Point,line and plane	2

		defects. Thermodynamics of Schottky and Frenkel defects.	
	6	Colour centers in alkali halide crystals. Defect clusters. Extended defects: Crystallographic shear structure and stacking faults. Dislocations and crystal structure.	2
	7	Structure of compounds of AX (Zinc blende, Wurtzite), AX_2 (Rutile, fluorite, antifluorite), A_mX_2 (Nickel arsenide), ABX_3 (Perosvskite, Ilmenite), Spinels.Inverse spinel structures.	2
II	**SOLID STATE CHEMISTRY**		**12**
	8	Electronic structure of solids. Free electron theory, band theory. Refinements to simple band theory, k space and Brillouin zones.	2
	9	Conductors, insulators and semiconductors. Band structure of conductors, insulators and semiconductorsand their applications.	2
	10	Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the bandgap.	2
	11	Temperature dependence of conductivity, carrier density and carrier mobility in semiconductors.	2
	12	Superconductivity, Photoconductivity, Photovoltaiceffect. Colour in inorganic solids.	2
	13	Dielectric properties. Dielectric materials. Ferroelectricity, pyroelectricity, piezoelectricity and ionic conductivity. Applications of ferro, piezo and pyroelectrics.	2
III	**CHEMISTRY OF NATURAL ENVIRONMENTAL PROCESSES**		**12**
	14	Chemistry of processes in atmosphere: Composition of the atmosphere. Automobile pollutants and the catalytic converter. Chemistry of the stratosphere. Catalytic destruction of ozone. Hazards of common air pollutants on the human health.	3.5
	15	Chemistry of processes in hydrosphere: The hydrologic cycle. Cycling and purification. -Activated charcoal, synthetic resins, reverse osmosis and electro dialysis. The unique properties ofwater. Acid-base properties.	4.5
	16	Chemistry of processes in Lithosphere: Redox status in soil. pE, pH predominance diagrams for redox sensitive elements Fe and Cr. Acidity in soil materials. Acid neutralization capacity and the quantification of the soil acidity. Ion speciation in soil solution. Cation exchange capacity and exchange phase composition.	4
IV	**ISOPOLY & HETEROPOLY ACIDS, SILICON-OXYGEN & XENON COMPOUNDS**		**12**
	17	Isopoly: Preparation, properties and structure of isopolyacids of Mo, W and V.	3
	18	Heteropoly acids: Heteropoly acids of Mo and W. Keggin Structure, Keggin anions, Polyoxometalates.	3
	19	Silicon-oxygen compounds: Aluminosilicates, Zeolites as microporous materials and molecular sieves,Silicones and Polysiloxanes.	3

	20	Xenon fluorides, Structure of XeF_2 (MO theory only), Perxenate ion, Organo xenon compounds, Coordination compounds of Xenon.	3
V	**OPEN ENDED MODULE:**		**12**
	21.	Learning through problem solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc	12

References:

1. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, John Wiley and Sons, 6th edition, 1999.
2. J. E. Huheey, *Inorganic Chemistry- Principles of Structure and Reactivity*, Harper Collins College Publishing, 4th edition, 2011.
3. S. F. A. Kettle, *Physical Inorganic Chemistry*, Oxford University Press, 1st edition, 1998.
4. K. F. Purcell and J. C. Kotz, *Inorganic Chemistry*, Saunders, 1977.
5. S. F. A. Kettle, *Physical Inorganic Chemistry*, Oxford University Press, 1st edition, 1998.
6. Shriver and Atkins, *Inorganic Chemistry*, Oxford University Press, 2010.
7. Douglas, D. H. Mc Daniel, J. J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn. John Wiley & Sons, 2006.
8. J. D. Lee, Concise *Inorganic Chemistry*, 5th Edn. Chapman & Hall, 1996.
9. A. R. West, *Solid State Chemistry and its Applications*, Wiley Eastern, 1990.
10. H. J. Emeleus and A. G. Sharp, *Modern Aspects of Inorganic Chemistry*, VanNostrand, 4th edition,1973.
11. L. V. Azaroff, *Introduction to Solids*, Mcgraw-Hill, 1960.
12. C. Kittel, *Introduction to Solid State Physics*, Wiley and Sons, 8th edition,2004.
13. E. James Girard, *Principles of Environmental Chemistry*, Jones and BartlettPublishers, 3rd Edition, 2013
14. H.V. Jadhav, *Elements of Environmental Chemistry*, Himalya PublicationHouse, 2010.
15. E. Michael Essington, *Soil and water Chemistry*, CRC Press, 2nd edition,2015.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Study, analyze and interpret various crystal structures of compounds, including binary and ternary compounds, and their applications in materials science and technology.	U, An	PSO-1,2
CO-2	Develop a knowledge on the behaviour of materials in various electronic applications, useful to design and	An,Ap	PSO-1,2,3

	optimize novel electronic devices and materials for technological advancements.		
CO-3	Knowing the chemical processes shaping our environment, enables to develop solutions for environmental challenges and make informed decisions to mitigate their impact on human health and ecosystems.	U, An	PSO-1,2,3
CO-4	An understanding in the structural features of isopoly and heteropoly acids, helps to explore their diverse applications in advanced research.	U, An, Ap	PSO-1,2,3,5
CO-5	Explore silicon-oxygen compounds and xenon fluorides, equip with the knowledge to innovate in materials science, catalysis, and coordination chemistry.	Ap, E	PSO-1,2
CO-6	Critical thinking, collaborative learning, and practical application of theoretical knowledge, preparing students to tackle real-world challenges in related topics.	E, C	PSO-1,2,3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ADVANCED INORGANIC CHEMISTRY II

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2	U, An	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	An, Ap	C, P	L	-
3	CO-3	PO-1,2,6 PSO-1,2,3	U, An	C	L	-
4	CO-4	PO-1,6 PSO-1,2,3,5	U, An, Ap	C	L	-
5	CO-5	PO-1,6	Ap, E	C	L	-

		PSO-1,2				
6	CO-6	PO-1,2,3,6 PSO-1,2,3,4,5	E, C	P, M	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	-	-	-	1	-	-	-	-	2	-	-
CO 2	3	2	1	-	-	1	1	-	-	-	2	-	-
CO 3	3	2	1	-	-	1	1	-	-	-	2	-	-
CO 4	3	2	1	-	1	2	1	-	-	-	2	-	-
CO 5	3	2	-	-	-	2	1	-	-	-	2	-	-
CO 6	3	3	2	1	2	2	2	2	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓			✓
CO 6	✓	✓	✓	

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK7DSCCHE402**				
Course Title	**ADVANCED ORGANIC CHEMISTRY**				
Type of Course	**DSC**				
Semester	7				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. UK2DSCCHE100, UK4DSCCHE202, UK5DSCCHE304, UK6DSCCHE302, UK6DSCCHE305				
Course Summary	The course covers advanced topics of supramolecular chemistry, green including atom economy evaluation, the use of green solvents, and innovative methods like microwave and sonochemical synthesis, organic synthesis techniques like retrosynthetic analysis, protecting group strategies, and combinatorial synthesis play vital roles in drug discovery and development. Organic practicals, including separation and identification techniques like TLC, provide hands-on experience crucial for understanding organic compound analysis.				

Detailed Syllabus:

Module	Unit	Content **ADVANCED ORGANIC CHEMISTRY II**	Hrs 75
I	**ADVANCED CONCEPTS IN MOLECULAR RECOGNITION AND SUPRAMOLECULAR CHEMISTRY**		**12**
	1	Forces involved in molecular recognition. Hydrogen bonding, ionic bonding, π-stacking, van der Waals and hydrophobic interactions	4
	2	Introduction to molecular receptors, tweezers, cryptands and carcerands, cyclophanes, cyclodextrins and calixarenes- typical examples.	4
	3	Importance of molecular recognition in DNA and protein structure, their function and protein biosynthesis	4
II	**ADVANCED GREEN CHEMISTRY**		**12**
	4	Twelve principles of green chemistry in detail. Green chemical strategies for sustainable development- Reaction mass balance, atom economy evaluation for chemical reaction efficiency, green solvents, reaction	4

		media- Synthesis under water, solventless, fluorous and ionic liquid media.	
	5	Green processes- microwave synthesis- fundamentals of microwave synthesis - Two principal mechanisms for Interaction with matter - The Microwave Effect with examples - Single-Mode and Multimode Microwave cavities.	4
	6	Sonochemical synthesis. Applications of sonication in the synthesis of organic compounds.	4
III	**METHODS IN ORGANIC SYNTHESIS**		**12**
	7	Retrosynthetic analysis and disconnection approachsynthons, synthetic strategy, reliable reaction, disconnect after heteroatom, chemoselectivity, two group disconnections (use of epoxide), creation of cis and trans double bonds, retro synthesis of amines.	4
	8	Protecting group strategy: Tetrahydropyranyl, silyl, tbutyl, trichloroethyl, acetal and thioacetal as hydroxyl, thiol, carboxyl and carbonyl protecting groups in synthesis.	4
	9	Introduction to combinatorial synthesis - split and pool method only**.**	4
IV	**MEDICINAL CHEMISTRY**		**9**
	10	Combinatorial organic synthesis, introduction, methodology, automation, solid supported and solution phase synthesis, study of targeted or focused libraries and small molecule libraries. Application - drug discovery.	3
	11	Drug design and development-Discovery of a drug, a lead compound.	3
	12	Development of drug-Pharmacophore identification, modification of structure, structureactivity relationship, structure modification to increase potency. Lipophilicity.	3
V	**ORGANIC PRACTICALS-SEPARATION AND IDENTIFICATION OF ORGANIC COMPOUNDS**		**30**
	13	Quantitative wet chemistry separation of a mixture of two components by solvent extraction. TLC of the purified samples along with the mixture in same TLC plates (component 1 with mixture and component 2 with mixture on separate TLC plate) and calculation of Rf values- Reporting and recording TLC in standard formats- preparation of sample solution, adsorbent, dimensions of the plate, saturation time, developing time, visualization and detection, Rf Value, Drawing - in the form of a table.	30

References:

1. A. Bahl and B. S. Bahl, *Advanced Organic Chemistry*, S.Chand& Company, New Delhi.
2. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, *A textbook of Organic Chemisty*, Vikas Publishing House (Pvt) Ltd., New Delhi..
3. S.C.Sharma and M.K.Jain, *Modern Organic Chemistry*, Vishal Publishing Company,New Delhi..

4. I L Finar, “*Organic Chemistry*” Vol – 1&2, 5th Edition, Pearson Education, New Delhi.
5. Helena Dodzuik, *Introduction to supramolecular chemistry*, Springer.
6. V.K.Ahluwalia, *Green Chemistry*, Enviornmentally Benign reaction, Ane Book.

For Further Reading:

1. R.T.Morrison, R.N.Boyd. *Organic Chemistry*, Pearson Education, New Delhi.
2. P.Y.Bruice, *Essential Organic Chemisty*, Pearson Education, New Delhi.
3. J.Clayden, N.Greeves and S.Warren, *Organic Chemistry*, Oxford University Press, New York.
4. Billmeyer F.W., *Text book of Polymer Science*, John Wiley and Sons.
5. S.P.Bhutani, *Chemistry of Biomolecules*, Ane Book Pvt Ltd.
6. L.M. Lehn, *Supramolecular Chemistry*, VCH.
7. M.M.Sreevastava and Rashmi Sanghi, *Green Chemistry for environment*, Narosa Publishing House.
8. Smith, Michael B, *Organic synthesis*, 4^{th} ed, Amsterdam Academic Press 2017.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	List out the forces involved in molecular recognition, recognise molecular receptors and quote molecular recognition events in biological systems.	U	PSO-1,2
CO-2	Appreciate and apply the principles of green chemistry in calculating the atom economy of various reactions.	R, U	PSO-1,2,3
CO-3	Propose retrosynthetic pathways and protecting group strategy to a variety of molecules.	U, An	PSO-1,2
CO-4	Explain various stages involved in drug design and development.	Ap, An	PSO-1,2,3
CO-5	Determine the correct method for separation of binary nixtures and development of TLC in determining purity of organic compounds.	Ap, An	PSO-1,2,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ADVANCED ORGANIC CHEMISTRY

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PSO-1,2	U	F	L	-
2	CO-2	PSO-1,2,3	R, U	F,C	L	-
3	CO-3	PSO-1,2	U,An	C	L	-
4	CO-4	PSO-1,2,3	Ap, An	F,C	L	-
5	CO-5	PSO-1,2,5	Ap, An	F	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	1	2	-	-	-	2	-	-	-	-	-	-	-
CO 2	2	3	2	-	-	2	2	-	-	-	-	-	-
CO 3	1	2	-	-	-	2	2	-	-	-	-	-	-
CO 4	1	2	2	-	-	2	2	-	-	-	-	-	-
CO 5	1	1	-	-	2	2	2	3	-	-	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5	✓	✓	✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK7DSCCHE403**				
Course Title	**ADVANCED PHYSICAL CHEMISTRY**				
Type of Course	**DSC**				
Semester	7				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5
Pre-requisites	1. Foundational courses in general chemistry and physical chemistry. 2. A solid understanding of principles in calculus and introductory physics 3. Exposure to laboratory techniques and instrumentation				
Course Summary	This course covers advanced topics in electrochemistry, irreversible thermodynamics, bioenergetics, chemical kinetics, and electroanalytical techniques, providing students with theoretical foundations and practical skills for chemical analysis and experimentation. Through comprehensive study and hands-on laboratory work, students gain expertise in understanding reaction mechanisms, thermodynamic processes, and analytical methods essential for research and industrial applications in chemistry.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**ELECTRO CHEMISTRY**		**12**
	1	Debye-Huckel theory of strong electrolytes, Debye-Huckel-Onsager equation and its derivation, limitation of the model. Ionic strength, mean ionic activity coefficient, Debye - Huckel limiting law.	3
	2	Different type of electrodes. Electrochemical cells, EMF of concentration cells, liquid junction potential and its determination, cells without liquid junction potential.	3
	3	Electrode double layer, electrode-electrolyte interface, different models of double layer-Helmholtz compact layer model, Guoy-Chapman model, Stern model, theory of multilayer capacity, electro capillary, Lippmann equation, membrane potential.	3
	4	Overvoltage, hydrogen and oxygen overvoltage, theories of overvoltage, Tafel equation and its significance, Butler-Volmer equation for simple electron transfer reactions, transfer coefficient, exchange current density, rate constants.	3
II	**IRREVERSIBLE THERMODYNAMICS AND BIOENERGETICS**		**9**

	5	Thermodynamics of irreversible processes with simple examples. Uncompensated heat and its physical significance. Entropy production-rate of entropy production, entropy production in chemical reactions, the phenomenological relations, the principle of microscopic reversibility, the Onsager reciprocal relations, thermal osmosis and thermoelectric phenomena.	4
	6	Bioenergetics: Coupled reactions, ATP and its role in bioenergetics, high energy bond, free energy and entropy change in ATP hydrolysis, thermodynamic aspects of metabolism and respiration, glycolysis, biological redox reactions.	5
III	**CHEMICAL KINETICS II**		**12**
	7	Transition state theory - Eyring equation. Comparison of Collision and Transition state theory. Potential energy surfaces	2
	8	Theories of unimolecular reactions - qualitative idea of RRKM theory. Kinetics of complex reactions- Parallel reactions, opposing reactions, consecutive reactions and chain reactions, Kinetics of H_2-Cl_2 reaction steady state treatment. Hinshelwood mechanism of chain reactions and explosion.	4
	9	Reactions in solution: Factors affecting reaction rates in solutions, effect of dielectric constant and ionic strength, cage effect, Bronsted-Bjerrum equation.	2
	10	Fast reactions: Relaxation method, flow method, shock method, pulse method, flash photolysis and NMR method.	2
	11	Kinetic effects: Primary and secondary kinetic salt effect, influence of solvent on reaction rates. significance of volume of activation, linear free energy relationship. Hammet equation and Taft equation.	2
IV	**ELECTROANALYTICAL TECHNIQUES**		**12**
	12	Voltametry -Cyclic voltametry, ion-selective electrodes, anodic stripping voltametry.	2
	13	Polarography -Decomposition potential, residual current, migration current, supporting electrolyte, diffusion current, polarogram, half wave potential, limiting current density, polarograph, explanation of polarographic waves, the dropping mercury electrode, advantages and limitations of DME, applications of polarography	4
	14	Amperometric titrations- General principles of amperometry, application of amperometry in the qualitative analysis of anions and cations in solution.	2
	15	Coulometry- Coulometer-Hydrogen Oxygen coulometers, silver coulometer, coulometric analysis with constant current, coulometric titrations, applications of coulometric titrations. complex formation titrations, redox titrations. Advantages of coulometry.	4
V	**PRACTICALS – PHYSICAL CHEMISTRY EXPERIMENTS**		**30**
	A minimum of 8 practical experiments out of which at least one each from sections I, II and III must be performed and reported.		
		I. Kinetics a) Determination of rate constant of acid hydrolysis of methyl acetate. b) Determination of Arrhenius parameters.	10

		c) Determination of concentration of given acid. d) Determination of rate constant of the saponification of ethyl acetate and evaluation of Arrhenius parameters. e) Determination of rate constant of reaction between $K_2S_2O_8$ and KI.	
		Thermochemistry a) Determination of the concentration of given strong acid/alkali. b) Thermometric titration of NaOH vs standard HCl. c) Heat of displacement of Cu 2+ by Zn. d) Determination of the heat of ionisation of acetic acid.	10
		Electrochemistry a) Verification of Onsager equation. b) Determination of the degree of ionization of weak electrolytes. c) Determination of pKa values of organic acids. d) Determination of solubility of sparingly soluble salts.	10

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Demonstrate a comprehensive understanding of electrochemical principles, to analyze and predict electrochemical phenomena in various applications.	U, An	PSO-1,2,3
CO-2	Possess a deep understanding of thermodynamics in irreversible processes and bioenergetics to analyze and interpret energy transformations in biological systems.	An, Ap	PSO-1,2,3
CO-3	Gain a thorough understanding of reaction kinetics theories to analyze and predict reaction rates in various environments and apply kinetic principles to chemical systems with accuracy and proficiency.	U, An	PSO-1,2,3
CO-4	Proficiency in electroanalytical techniques to analyse and quantify analytes accurately and efficiently in various chemical and biological samples.	An, Ap	PSO-1,2,3,4,5
CO-5	Proficiency in experimental techniques and data analysis within kinetics, thermochemistry, and electrochemistry	E	PSO-1,2,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ADVANSED PHYSICAL CHEMISTRY I

Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	U, An	F, C	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	An, Ap	F, C	L	-
3	CO-3	PO-1,2,3,6 PSO-1,2,3	U, An	F, C	L	-
4	CO-4	PO-1,6,7 PSO-1,2,3,4,5	An, Ap	P	L	-
5	CO-5	PO-1,2,6 PSO-1,2,3	E	P	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	-	-	2	-	-	-	-	2	-	-
CO 2	3	3	2	-	-	2	1	-	-	-	2	-	-
CO 3	3	3	2	-	-	2	1	1		-	2	-	-
CO 4	2	2	2	1	2	2	-	-	-	-	2	2	-
CO 5	3	3	3	2	2	2	2	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5	✓		✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK7DSCCHE404**				
Course Title	**ADVANCED THEORETICAL CHEMISTRY I**				
Type of Course	**DSC**				
Semester	7				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	1. Idea about translational, rotational and vibrational motions and simple harmonic oscillator. 2. Mathematical prerequisites - basic understanding of differentiation, partial differentiation, integration, technique of separation of variables. Cartesian and spherical polar coordinate systems.				
Course Summary	The course introduces the fundamentals of quantum mechanics and application of quantum mechanics to translational, rotational and vibrational motions. Discussions about spherical harmonics and angular momentum is presented. Also fundamentals of group theory and various steps for the construction of character table will be obtained from this course.				

Detailed Syllabus:

Module	**Unit**	**Content** **ADVANCED THEORETICAL CHEMISTRY I**	**Hrs** **60**
I	**INTRODUCTION TO QUANTUM CHEMISTRY**		**9**
	1.1	Black body radiation and Planck's quantum postulate. Einstein's photoelectric equation, Schrodinger's wave mechanics.	**1**
	1.2	Detailed discussion of postulates of quantum mechanics – State function or wave function postulate, Born interpretation of the wave function, well behaved functions, orthonormality of wave functions.	**2**
	1.3	Operator postulate, operator algebra, linear and nonlinear operators, non-commuting operators and the Heisenberg's Uncertainty principle, Laplacian operator.	**2**
	1.4	Hermitian operators and their properties, eigen functions and eigen values of an operator; Eigen value postulate, eigen value equation.	**2**
	1.5	Expectation value postulate; Postulate of time-dependent Schrödinger equation of motion.	**1**

	1.6	Conservative systems and time independent Schrödinger equation. Stationary states.	**1**
II	**QUANTUM MECHANICS OF TRANSLATIONAL & VIBRATIONAL MOTIONS**		**12**
	2.1	Free particle in one-dimension; Particle in a one-dimensional box with infinite potential walls, important features of the problem.	**2**
	2.2	Particle in a one-dimensional box with one finite potential wall, Particle in a rectangular well, (no derivation), Significance of the problem, Introduction to tunneling.	**3**
	2.3	Particle in a three-dimensional box, Separation of variables, degeneracy, Symmetry breaking.	**3**
	2.4	One-dimensional harmonic oscillator (complete treatment):- Method of power series, Hermite equation and Hermite polynomials, recursion relation, wave functions, and energies, important features of the problem, harmonic oscillator model and molecular vibrations.	**4**
III	**QUANTUM MECHANICS OF ROTATIONAL MOTION**		**12**
	3.1	Co-ordinate systems: - Cartesian, and spherical polar coordinates and their relationships.	1
	3.2	Planar rigid rotor (or particle on a ring), the Phi-equation, solution of the Phi-equation.	2
	3.3	One particle Rigid rotator (non-planar rigid rotator or particle on a sphere) (complete treatment). The wave equation in spherical polar coordinates, separation of variables, the Phi-equation and the Theta-equation and their solutions.	3
	3.4	Legendre and associated Legendre equations, Legendre and associated Legendre polynomials, Rodrigue's formula.	2
	3.5	Spherical harmonics (imaginary and real forms), polar diagrams of spherical harmonics.	1
	3.6	Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta ((L_x, L_y, L_z), commutation relations between these operators, Ladder operator method for angular momentum, space quantization.	3
IV	**FOUNDATIONS OF GROUP THEORY & MOLECULAR SYMMETRY**		**9**
	4.1	Basic principles of group theory - the defining properties of mathematical groups, finite and infinite groups, Abelian and cyclic groups, group multiplication tables (GMT), similarity transformation, sub groups & classes in a group.	2
	4.2	Molecular Symmetry & point groups - symmetry elements and symmetry operations in molecules, relations between symmetry operations, complete set of symmetry operations of a molecule.	2
	4.3	Point groups and their systematic identification, GMT of point groups.	2
	4.4	Mathematical preliminaries - matrix algebra, addition and multiplication of matrices, inverse of a matrix, square matrix, character of a square matrix, diagonal matrix, direct product and direct sum of square matrices, block factored matrices, solving linear equations by the method of matrices; Matrix representation of symmetry operations.	3

V	**REPRESENTATIONS OF POINT GROUPS & CORRESPONDING THEOREMS**		**18**
	5.1	Representations of point groups - basis for a representation, representations using vectors, atomic orbitals and Cartesian coordinates positioned on the atoms of molecule (H_2O as example) as bases.	2
	5.2	Reducible representations and irreducible representations (IR) of point groups, construction of IR by reduction (qualitative demonstration only).	2
	5.3	Great Orthogonality Theorem (GOT) (no derivation) and its consequences.	2
	5.4	Derivation of characters of IR using GOT, construction of character tables of point groups (C_{2V}, C_{3V}, C_{2h} and C_{4V} and C_3 as examples).	5
	5.5	Nomenclature of IR- Mulliken symbols, symmetry species.	2
	5.6	Reduction formula - derivation of reduction formula using GOT, reduction of reducible representations, (e.g., Γcart) using the reduction formula.	3
	5.7	Relation between group theory and quantum mechanics – wave functions (orbitals) as bases for IR of point groups.	2

Books and References:

1. D. A. McQuarrie, Quantum Chemistry, Viva, 2016.
2. F.L. Pilar, *Elementary Quantum Chemistry*, McGraw-Hill, 1968.
3. I.N. Levine, *Quantum Chemistry*, 6th Edition, Pearson EducationInc.,
4. P.W.Atkins and R.S.Friedman,*Molecular Quantum Mechanics*, 4th Edition, Oxford University Press,2005.
5. M.W. Hanna, *Quantum Mechanics in Chemistry*, 2nd Edition, W.A. Benjamin Inc., 1969.
6. Thomas Engel, Quantum Chemistry & Spectroscopy, Pearson Education, 2006.
7. J.P. Lowe, *Quantum Chemistry*, 2nd Edition, Academic Press Inc., 1993.
8. HoriaMetiu, *Physical Chemistry – Quantum Mechanics*, Taylor & Francis, 2006.
9. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, 1994.
10. L. Pauling and E.B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill,1935.
11. R.L. Flurry, Jr., *Quantum Chemistry*, Prentice Hall, 1983.
12. R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.
13. M.S. Pathania, *Quantum Chemistry, and Spectroscopy*, Vishal Publications, 1984.
14. M.C. Day, J Selbin, Theoretical inorganic chemistry. 2nd Edition, 2008.
15. F.A. Cotton, *Chemical applications of Group Theory*, 3rdEdition, John Wiley &Sons Inc.,2003.
16. Salahuddin Kunju & G. Krishnan, *Group Theory & its Applications in Chemistry*, PHI Learning Pvt. Ltd.2010.
17. H. H. Jaffe and M. Orchin, *Symmetry in Chemistry*, John Wiley &Sons Inc., 1965.
18. K.Veera Reddy, *Symmetry & Spectroscopy of Molecules 2nd Edn.*, New Age International 2009.

19. L.H. Hall, *Group Theory and Symmetry in Chemistry*, McGraw Hill, 1969.
20. L. Carter Robert, Molecular Symmetry and Group Theory, John Wiley & Sons, 2009.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	*Recognize* the importance and the impact of quantum mechanics in the revolution in science.	R	PSO-1,2,3
CO-2	*apply* the concept of particle in one dimensional box model to translational motion and harmonic oscillator model to vibrational motion.	Ap	PSO-1,2,3
CO-3	*correlate* the concept of rotational motion to spherical harmonics and angular momentum.	An	PSO-1,2,3
CO-4	*explains* the mathematical preliminaries of matrix algebra and relate matrix properties with symmetry.	R, U	PSO-1,2,3
CO-5	*construct* the character tables of various point groups and connects group theory with quantum mechanics.	C, An	PSO-1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ADVANCED THEORETICAL CHEMISTRY I

Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	R	F	L	-
2	CO-2	PO-1,2,6 PSO-1,2,3	Ap	C	T	-
3	CO-3	PO-1,2,6 PSO-1,2,3	An	C	T	-
4	CO-4	PO-1,2,6 PSO-1,2,3	R, U	P	L/T	-

5	CO-5	PO-1,2,6 PSO-1,2,3,5	C, An	C	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	1	-	-	1	-	-	-	-	2	-	-
CO 2	2	3	1	-	-	1	1	-	-	-	2	-	-
CO 3	3	2	1	-	-	1	1	-	-	-	2	-	-
CO 4	3	2	1	-	-	1	1	-	-	-	2	-	-
CO 5	2	2	1	-	2	1	1				2		

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5			✓	✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK7DSCCHE405</td></tr>
<tr><td>Course Title</td><td colspan="5">ADVANCED THEORITICAL CHEMISTRY II</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">7</td></tr>
<tr><td>Academic Level</td><td colspan="5">300-399</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>4 hours</td><td>-</td><td>-</td><td>4</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">1.Basic knowledge about fundamentals of quantum mechanics.
2.The learners must have an idea about the quantum mechanics of rotational and vibrational motions, spherical harmonics and about character tables of various point groups.</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course gives a novel understanding about the quantum mechanics of hydrogen atom and similar systems. The need for approximation techniques and how to treat multi electron systems is well presented in this course. Understanding about chemical bonding in the quantum mechanical perspective and steps for identification of IR and Raman active vibrational modes in molecules will also be obtained from this course.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content ADVANCED THEORITICAL CHEMISTRY II	60 Hrs
I	**QUANTUM MECHANICS OF HYDROGEN-LIKE ATOMS**		**9**
	1.1	Potential energy of hydrogen-like systems, the wave equation in spherical polar coordinates.	2
	1.2	Separation of variables, the R, θ and ϕ equations and their solutions, Laguerre and associated Laguerre polynomials.	2
	1.3	Wave functions and energies of hydrogen-like atoms, orbitals, radial functions and radial distribution functions and their plots, angular functions (spherical harmonics) and their plots.	3
	1.4	The postulate of spin by Uhlenbeck and Goudsmith, Dirac's relativistic equation for hydrogen atom and discovery of spin (qualitative treatment), spin orbitals, construction of spin orbitals from orbitals and spin functions.	2
II	**APPROXIMATION METHODS IN QUANTUM MECHANICS**		**9**

	2.1	Many bodies problem and the need of approximation methods; Independent particle model.	1
	2.2	Variation method – variation theorem with proof, Linear variation functions. Secular equations and secular determinants. Illustration of variation theorem using a trial function [e.g., x (a-x)] for particle in a 1D-box, variation treatment for the ground state of helium atom.	4
	2.3	Perturbation method – time independent perturbation method (non-degenerate case only), illustration by application to particle in a ID-box with slanted bottom, perturbation treatment of the ground state of the helium atom.	4
III	**QUANTUM MECHANICS OF MANY-ELECTRON ATOMS**		**9**
	3.1	Hartree's Self-Consistent Field method for atoms.	3
	3.2	Fock modification using spin orbitals & Hartree Fock Self- Consistent Field (HF-SCF) method for atoms, the Fock operator.	2
	3.3	Pauli's antisymmetry principle - Slater determinants.	2
	3.4	Roothan's concept of basis functions: Slater type orbitals (STO) and Gaussian type orbitals (GTO).	2
IV	**CHEMICAL BONDING**		**15**
	4.1	MO theory - The Born-Oppenheimer approximation –MO Theory-LCAO MO method applied to H_2 and H_2^+.	3
	4.2	MO diagram of homo nuclear diatomic molecules Li_2, Be_2, B_2, C_2, O_2 and F_2 and hetero nuclear diatomic molecules LiH CO, NO and HF.	2
	4.3	Spectroscopic term symbols for homodiatomic molecules, selection rules for molecular spectra.	2
	4.4	Valance bond theory - VB treatment of hydrogen molecule only. Comparison of MO and VB theories.	2
	4.5	Quantum mechanical treatment of sp, sp2 and sp3 hybridization.	3
	4.6	HMO theory of conjugated systems. Bond order and charge density calculations, free valance. Application of HMO method to ethylene, allyl, butadiene and benzene systems.	3
V	**APPLICATIONS OF GROUP THEORY TO MOLECULAR SPECTROSCOPY AND HYBRIDIZATION**		**18**
	5.1	Molecular vibrations - symmetry species of normal modes of vibration, construction of Γcart, normal coordinates and drawings of normal modes (e.g., H_2O and NH_3).	2
	5.2	Spectral transition probabilities - direct product of irreducible representations and its use in identifying vanishing and non–vanishing integrals, transition moment integral and spectral transition probabilities.	2
	5.3	Selection rules for IR and Raman activities based on symmetry arguments.	2
	5.4	Determination of IR active and Raman active modes of molecules (e.g., H_2O, NH_3, CH_4, SF_6).	4

	5.5	Complementary character of IR and Raman spectra. Rationalization of rule of mutual exclusion principle using group theory.	2
	5.6	Electronic Spectra – electronic transitions and selection rules (HCHO molecule as example), Laporte selection rule for centro symmetric molecules.	3
	5.7	Hybridisation - Identification of atomic orbitals taking part in hybridisation of triangular planar, square planar, trigonal bipyramidal, square pyramidal and tetrahedral molecules. Inverse transformation and construction of hybrid orbitals of BF_3 and CH_4 molecules.	3

Books and References:

1. Donald, A. McQuarrie, *Quantum Chemistry*, University Science Books, 1983 (Viva books, 2003).
2. Thomas Engel, *Quantum Chemistry & Spectroscopy*, Pearson Education, 2006.
3. P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics*, 4th Edition, Oxford University Press, 2005.
4. F.L. Pilar, *Elementary Quantum Chemistry*, McGraw-Hill, 1968.
5. I.N. Levine, *Quantum Chemistry*, 6th Edition, Pearson EducationInc.,
6. M.W. Hanna, *Quantum Mechanics in Chemistry*, 2nd Edition, W.A. Benjamin Inc., 1969.
7. R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.
8. J.P. Lowe, *Quantum Chemistry*, 2nd Edition, Academic Press Inc., 1993.
9. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, 1994.
10. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn., John Wiley & Sons, NewYork, 1990.
11. A. Salahuddin Kunju & G. Krishnan, Group Theory & its Applications in Chemistry, PHI Learning Pvt. Ltd.2010.
12. L. Carter Robert, Molecular Symmetry and Group Theory, John Wiley & Sons, 2009.
13. K. Veera Reddy, Symmetry and Spectroscopy of molecules, New Age International, 2005.
14. P. S. Sindhu, Fundamentals of Molecular Spectroscopy, New Age International, 2006.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	*relate* the principles of rotational motion, rigid rotor and spherical harmonics for solving hydrogen like systems.	Ap	PSO-1,2,3
CO-2	*realise* the limitation of many body problem and explore the utility of approximation techniques.	An	PSO-1,2,3
CO-3	*identify* the procedural technique applied for treating	C	PSO-1,2,3

	multi electron system		
CO-4	*apply* various theories for explaining bonding in molecules	Ap	PSO-1,2,3
CO-5	*apply* the principles of group theory for evaluating IR and Raman active vibrational modes in molecules	E	PSO-1,2,3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: ADVANCED THEORITICAL CHEMISTRY II

Credits: 4:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	PO-1,6 PSO-1,2,3	Ap	C	L	-
2	CO-2	PO-1,6 PSO-1,2,3	An	C/P	T	-
3	CO-3	PO-1,6 PSO-1,2,3	C	P	L/T	-
4	CO-4	PO-1,2,6 PSO-1,2,3	Ap	C	T	-
5	CO-5	PO-1,2,3,6 PSO-1,2,3,5	E	M	L/T	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	1	-	-	1	-	-	-	-	2	-	-
CO 2	3	2	1	-	-	1	-	-	-	-	2	-	-
CO 3	3	2	1	-	-	1	-	-	-	-	2	-	-
CO 4	3	2	1	-	-	2	1	-	-	-	2	-	-
CO 5	3	2	1	-	2	2	1	1	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5			✓	✓

University of Kerala

Discipline	CHEMISTRY				
Course Code	**UK7DSECHE400**				
Course Title	**RESEARCH METHODOLOGY AND ETHICS**				
Type of Course	**DSE**				
Semester	7				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-	-	4
Pre-requisites	A foundational understanding of chemistry principles and laboratory techniques, proficiency in basic mathematics and statistics, and familiarity with scientific literature and research methodologies.				
Course Summary	This course in Research Methods in Chemistry covers the fundamentals of formulating research problems, hypothesis testing, data analysis techniques, and utilizing online and library resources. It emphasizes statistical methods and correlation analysis, along with laboratory safety practices and ethical considerations in research.				

Detailed Syllabus:

Module	Unit	Content **RESEARCH METHODOLOGY AND ETHICS**	Hrs 60
I	**THE RESEARCH PROBLEM**		**9**
	1.1	Designing and formulating a research problem, characteristics of a good research problem	2
	1.2	Hypothesis- – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis, Hypothesis Testing – Logic & Importance	3
	1.3	Information mining – online and library resources, literature survey, abstracts, journals, reviews	2
	1.4	Data sources, current awareness, research plan, experimental design, degrees of freedom	2
II	**DATA ANALYSIS**		**9**
	2.1	Errors – types of errors, analysis and interpretation of errors	2
	2.2	Accuracy and precision, significant figures	2
	2.3	Mean and standard deviation, confidence interval	2
	2.4	Student t-test, F-test and Q-test	1
	2.5	Correlation and regression analysis, regression coefficient, correlation co-efficient, correlograms, logarithmic and sigmoid curves	2
III	**USE OF COMPUTERS IN CHEMISTRY AND LABORATORY SAFETY**		**18**

	3.1	Internet resources for chemistry, databases, finding and citing information, applications and uses of common softwares in chemistry – origin, chemsketch, chemdraw, open-source computational chemistry softwares	3
	3.2	Using spreadsheets, word processors and power points	1
	3.3	General aspects of scientific writing, communications, notes and reviews, Formatting reports, data presentation – figures, graphs, tables, histograms and pi-diagrams	3
	3.4	Bibliography, referencing and footnotes	1
	3.5	Layout of a Research Paper, Impact factor of Journals	2
	3.6	General safety and operational rules, safety equipments, personal protective equipments	2
	3.7	Safety practices for disposing waste solvents, chemicals and broken glasswares, Fires, types of fire extinguishers and their usage	3
	3.8	Safety measures to be taken while using various instruments, MSDS Good laboratory practices, health issues and first-aid measures	3
IV	**ETHICS IN RESEARCH**		**9**
	4.1	Ethical issues in research -ethical committees-commercialisation-environmental impacts	3
	4.2	Plagiarism and Self-Plagiarism- reproduction of published material-reproducibility and accountability, copy rights, royalty	3
	4.3	Intellectual Property Rights and Patent law, citation and acknowledgement	3
V	**Open Ended Module: Learning through problem-solving, seminars, open discussions, assignment discussions, Quizzes, Open book exams etc.**		**12**
	1.	Explore the origins and development of computational chemistry software.	
	2.	Write an assignment on the Practical applications of open-source computational chemistry software in research.	
	3.	Utilize open-source computational chemistry software for molecular simulations.	
	4.	Compare and contrast the features of popular open-source computational chemistry software like Avogadro and PyMOL.	
	5.	Discuss on the essential components of a research proposal in chemistry.	
	6.	Discuss strategies for effectively communicating complex scientific concepts in an oral presentation.	
	7.	Create posters for chemistry poster presentation on specific topics by effectively incorporating visuals and data.	
	8.	Explore the advantages of LaTeX over MS Office for paper formatting in chemistry.	
	9.	Conduct a workshop on manuscript preparation: Formatting, referencing, and submitting to journals.	
	10.	Discuss the importance of clear and concise communication in scientific presentations.	
	11.	Compare the structure of a thesis differ from that of a research paper or project report.	

References

1. Kothari C R, *Research Methodolgy: Methods and Techniques*, New Age Intl, 1990.
2. *Practical Skills in Chemistry*, J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers and A Jones, Pearson Education Ltd. Prentice Hall, 2002.
3. *Statistics and chemometry for analytical chemistry*, J. N Miller, J. C Miller, Pearson Prentice Hall 2005.
4. F. Jensen, "*Introduction to Computational Chemistry*", 2nd Edition, Wiley, 1999.
5. Wadehra B L, *Law relating to Patents, trademarks*, copyright designs and geographical indications, universal Law Publ, 2000.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Identify and articulate research problems relevant to the field of study, will learn to formulate hypotheses, will develop research plans and experimental designs, considering degrees of freedom.	U	1,2,3
CO-2	Learn about types of errors in data analysis and methods for error analysis and interpretation and will be proficient in statistical tests.	E, U	1,2,3
CO-3	Explore the applications and uses of common software tools in chemistry, including ChemSketch, ChemDraw, and computational chemistry software and get proficiency in using spreadsheets, word processors, and presentation software for scientific communication.	Ap, C	1,2,5
CO-4	Develop skills in scientific writing, including note-taking, review writing, and report formatting. learn to present data effectively and understand the importance of proper citation and referencing in academic writing.	C, Ap	1,3
CO-5	Recognize and address ethical issues in research, including the role of ethical committees and the impact of commercialization and environmental factors.	R, U	1,5
CO-6	Understands the importance of safety measures while working in a lab and is aware of the principles to be	U, Ap	1,2,4,5

	followed in a lab and first aid to be taken in case of accidents in lab		

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: RESEARCH METHODOLOGY AND ETHICS

Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	CO-1	1,2,3	U	F, C	L	
2	CO-2	1,2,3	E, U	P, M	T	
3	CO-3	1,2,5	Ap, C	P	T	
4	CO-4	1,3	C, Ap	C, P	T	
5	CO-5	1,5	R, U	M	L	
6	CO-6	1,2,4,5	U, Ap	F, P	T	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

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CO 3	-	3	-	-	-	2	2	2	-	-	2	3	
CO 4	2	-	2	-	-	3	2	-	3	-	-	-	-
CO 5	-	-	2	-	3	2	2	-	-	-	-	-	2
CO6	-	3	-	3	-	1	-	-	-	-	1	-	2

Correlation Levels:

Level	Correlation
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CO 3	✓			✓
CO 4	✓	✓		✓
CO 5			✓	✓