University of Kerala

Four Year Under Graduate Programme

(UoK FYUGP)

Syllabus

Major Discipline Polymer Chemistry

May 2024

About the Discipline

The Four-Year Undergraduate Programme in Polymer Chemistry covers Four academic years of eight semesters and aims to provide the students with an in-depth understanding and training in chemical sciences. The syllabus has been designed to stimulate the interest of the students in polymer chemistry and prepared in order to equip the students with a potential to contribute to the academic and industrial Requirements of the society. The new, updated syllabus is in accordance with the Outcome Based Education (OBE) which aim at acquiring advanced knowledge in Polymer Chemistry as a discipline, in an interdisciplinary way. Based on the new guidelines of OBE, Programme Outcome (PO) for the Programme is defined by University of Kerala. Programme Specific Outcome (PSO) relating to FYUGP in Polymer Chemistry and Course Outcome (CO) relating to each course are also specified. [CO is of the Remember level (R) understand level (U) and apply level (A) based on Blooms Taxonomy]

Polymer Chemistry being an experimental science, due importance is given to the development of laboratory and instrumentation skills. The student is acquainted with the method of science and research methodology. At the same time, emphasis is given to critically analyse the impact of Polymer Chemistry in the present scenario of emerging human friendly and eco-friendly green approach in various facets of life and to become cautious against the random usage of dangerous chemicals.

It also provides a detailed knowledge of the terms, concepts, methods, principles and experimental techniques of chemistry, in order to get a comprehensive knowledge in leading a better life in harmony with nature.

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.

Programme Outcomes (PO)

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

Programme Specific Outcomes (PSO)

No.	Upon completion of the programme the graduate will be able to
PSO-1	Understand the terms, concepts, methods, principles and experimental techniques of physical, organic, inorganic and polymer chemistry and predict reaction mechanism in organic and polymer reactions that contribute to the academic and industrial requirements of the society.
PSO-2	Apply physical and mathematical theories and principles in the context of chemical science
PSO-3	Employ safety of chemicals, transfer and measurement of chemical, preparation of solutions, and find out the green route for polymer synthesis for sustainable development and develop skill in safe handling of chemicals including hazardous materials.
PSO-4	Develop skills in technical writing like lab record, research paper, scientific communication, presentation and skills in handling the instruments used in organic, inorganic, physical and polymer experiments.
PSO-5	Select appropriate polymer materials based on specific applications considering their mechanical properties, thermal stability and environmental to design and carry out polymer synthesis including polymerisation reactions and processing methods like extrusion, molding and film formation.
PSO-6	Demonstrate problem solving abilities required for successful career in pharmaceuticals, chemical industry, polymer industry teaching, research, environmental monitoring, product quality, consumer goods industry, food products, cosmetics industry, etc.

PSO-7	Generate scientific outlook, scientific attitude, and scientific temper, research attitude skill in experimenting, analyzing and interpreting data and analysing and solving research problems
PSO-8	Create healthier attitudes towards individual, community and culture, eco-friendly approaches and develop awareness of the impact of polymers on the environment, society by estimating environmental aspects and impact of chemicals in soil, water and air.

University of Kerala

Discipline	POLYMER CHEMISTRY				
Course Code	**UK1DSCPOC101**				
Course Title	Fundamentals of 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. A basic idea of types of bonds in chemistry 2. An understanding of the periodic table. 3. Principles of Analytical Chemistry 4. Basic knowledge regarding polymers				
Course Summary	This course provides an understanding of the origin of modern chemistry, various types of bonding and their theories, periodic properties and classification of elements. It is also intended to provide basic concepts in Qualitative & Quantitative Analysis.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**General Introduction to Chemistry**	**9**
	1	Ancient speculations on the nature of matter, Alchemy- early form of chemistry. The origins of modern chemistry, Antoine Lavoisier and the revolution in chemistry.	3
	2	Chemical atomism- John Dalton, Atom models of J.J. Thomson, Ruther Ford and Bohr. Major contributions of Friedrich Wohler, Dmitri Mendeleev, Michael Faraday and Marie Sklodowska- Curie.	2
	3	Chemistry as the central science, Structure of chemical science: scope of chemical science, Branches of chemistry.	2
	4	Evolution of nanoscience and its basic aspects, Carbon nanotubes and fullerenes, Applications– in electronics, robotics, sensors, medicine.	2
II		**Atomic Structure**	**9**
	5	Introduction to structure of atom, Rutherford and Bohr model of atom, Dual nature of electron-de Broglie equation, Matter waves and electromagnetic waves.	2

	6	Black body radiation, Photoelectric effect, Experimental verification by Davisson and Germer method, Heisenberg's uncertainty principle, Expression and significance.	3
	7	Wave mechanical concept of the atom-Schrodinger equation and its significance (derivation not required.), Normalized and orthogonal wave functions, Sign of wave functions, Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves.	4
III		**Periodic Classification of Elements**	**9**
	8	Quantum numbers and their significance, Concept of orbitals. Orbital wise electron configuration, energy sequence rule – Pauli's principle, Hund's rule, stability of filled and half-filled orbitals	2
	9	Modern periodic law – Long form periodic table. Diagonal relationship and anomalous behavior of first element in a group.	2
	10	Periodic Properties: Size of atoms & ions, ionization energies, electron affinity, Fajan's rule, electronegativity. Electronic configuration and classification of elements in to s,p,d and f blocks.	2
	11	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.	3
IV		**Analytical Principles-I**	**9**
	12	Qualitative analysis - Principles involved in the precipitation of compounds of cations - Solubility product and Common ion effect in the Precipitation of cations - Intergroup separation of Cations - Interfering acid radicals.	2
	13	Titrimetric analysis - fundamental concepts. Methods of expressing concentration: Weight percentage, Molality, Molarity, Normality, Mole fraction, ppm and ppb. Primary and Secondary standards, Quantitative dilution and Problems.	3
	14	Volumetric analysis- Principles of acid–base, redox, precipitation & complexometric titrations. Gravimetric analysis - Factors affecting the Solubility of precipitates. Colorimetric methods - theory & applications	2
	15	Separation and Purification techniques – Filtration, Crystallization and Precipitation, Fractional distillation.	2
V		**Introduction to Polymer Chemistry**	**9**
	16	Brief history of macromolecular science, general, characteristics of polymers in comparison with common organic compounds. Applications.	2
	17	Monomer & polymer, definition. Classification - natural, synthetic & semisynthetic. Nomenclature based on source, nomenclature based on structure (non-IUPAC), nomenclature based on structure IUPAC, trade names.	2
	18	Distinction between plastics, elastomers and fibres Preparation properties and applications of Plastics. Thermoplastic and thermosetting polymers.	2
	19	Natural polymers- cellulose, silk, gums and resin. Types of polymerizations –Chain and step polymerization – Homo polymers and Co-polymers – Synthesis and application of Polyethylene.	3

Fundamentals of Chemistry Practical – 30 Hours

Content		Hrs
Module I	**General Instructions**	**10**
1	Readiness to follow Laboratory rules and regulations and cooperating with Lab instructors and staff for avoiding accidents.	3
2	Laboratory safety measures, develop safety skills by wearing lab coats, gloves and safety eye glasses wherever necessary (Necessity of FIRST AID and of keeping first Aid box in Lab).	3
3	Procedures adopted in chemical splashes to skin, eyes, burns and electric shock, Instruction for emergency use of Fire extinguishers in Lab.	2
4	Labels and warning symbols for Safe handling of Toxic and corrosive chemicals. Familiarization of MSDS of common laboratory chemicals.	2
Module II	**Preparation of Standard Solutions**	**20**
6	Calculation of mass of a primary standard substance and preparing its standard solution (use of constant boiling hydrochloric acid and Analytical Grade Reagents is recommended)	2
7	Preparation of a solution of definite strength by Dilution techniques	2
8	Preparation of carbonate free sodium hydroxide.	2
9	**Acidimetry and Alkalimetry**	
10	Standardization of HCl using Analytical Grade Na_2CO_3	2
11	Titrations of Strong acid (HCl, HNO_3 and H_2SO_4) by strong bases (NaOH, KOH)	2
12	Strong base (NaOH, KOH) - weak acid (Oxalic acid)	2
13	Strong acid - (HCl, HNO_3 or H_2SO_4) by weak base (Na_2CO_3 solution)	2
14	Determination of Na_2CO_3 and $NaHCO_3$ in a mixture by indicator method	3
15	Estimation of NH_3 in an ammonium salt by direct and indirect methods	3

References

1. Soti Sivendra Chandra, Contemporary Science Teaching, Surjeet Publications, 2002.
2. N.C. Datta, The Story of Chemistry, University Press, 2005.
3. B. R. Puri, L. R, Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 33rd Ed. 2020.
4. Vogel, Text book of Quantitative Inorganic Analysis, 1989.
5. F. W. Billmayer, Text book of Polymer Science, 3rd edition, John Wiley & Sons, 1984.
6. V. R. Gowariker, N. V. Viswanathan &J. Sreedhar, Polymer Science, New Age International Publishers 2005.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Awareness about ancient and modern chemistry, Appraise the revolutions in chemistry.	**U**	**1**

CO-2	Understand evolution of nanoscience and its basic aspects, Applications of nanoscience in electronics, robotics, sensors, and medicine.	**U**	**1**
CO-3	Gain knowledge regarding Octet rule, Fajans rule. Understand various theories of chemical bonding and prediction of geometry of molecules through hybridisation.	**U**	**2**
CO-4	Acquire basic knowledge regarding Quantum Numbers, modern periodic table, periodic properties, characteristics of representative elements and transition elements.	**U**	**2**
CO-5	Understand the theory of qualitative chemical analysis, fundamental concepts of quantitative analyses viz. volumetric, gravimetric, and colourimetric analyses. Awareness about various Separation and purification techniques	**U, Ap**	**3**
CO-6	Brief history of macromolecular science, polymers, elastomers, plastic and natural polymers. Nomenclature, Polymerization techniques	**U**	**5**

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)
CO-1	Awareness about ancient & modern chemistry	**1/1**	**U**	**C**	**L**	
CO-2	Understand evolution & applications of nanoscience.	**1/1**	**U**	**C**	**L**	
CO-3	Gain knowledge regarding Octet rule, theories of bonding and hybridisation.	**1 /2**	**U**	**C**	**L**	
CO-4	Discussions on periodic table, periodic properties etc.	**1/2**	**U**	**C**	**L**	

CO-5	Theory of qualitative and quantitative analyses.	**2/3**	**U, Ap**	**C**	**L**	**P**
CO-6	History of polymers, plastics, and natural polymers, polymerization techniques	**3/5**	**U**	**C**	**L**	

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

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO3	PSO5	PO1	PO2	PO3
CO 1	2	-	-	-	1	-	-
CO 2	2	-	-	-	2	-	-
CO 3	-	2	-	-	2	-	-
CO 4	-	2	-	-	2	-	-
CO 5	-	-	2	-	-	3	-
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	✓		✓	✓

<table>
<tr><td>Discipline</td><td colspan="5">POLYMER CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UKIDSCPOC102</td></tr>
<tr><td>Course Title</td><td colspan="5">Introductory Organic Chemistry I</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">1</td></tr>
<tr><td>Academic Level</td><td colspan="5">100-199</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">Learned the naming of organic compounds
Understand the basic concepts of organic chemistry
Studied hydrocarbons, halogen compounds, alcohols, ethers etc
An understanding of importance of natural polymers</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course introduces students to the fundamental principles of organic chemistry, covering the structure, bonding, and nomenclature of organic molecules. Students will explore the significance of functional groups in determining chemical properties and learn about the diverse characteristics of hydrocarbons. Additionally, the course delves into the structures and importance of natural polymers, providing a foundational understanding of organic chemistry in both chemical and biological contexts.</td></tr>
</table>

Detailed Syllabus

<table>
<tr><th>Module</th><th>Unit</th><th>Content</th><th>Hrs</th></tr>
<tr><td rowspan="3">I</td><td colspan="2">Basics of Organic Chemistry</td><td>9</td></tr>
<tr><td>1</td><td>General introduction, tetravalence of carbon: shapes of organic compounds, structural representations of organic compounds, classification of organic compounds-Acyclic or open chain compounds and Alicyclic or closed chain or ring compounds.</td><td>5</td></tr>
<tr><td>2</td><td>Aromatic compounds, Benzenoid aromatic compounds, Non-benzenoid compounds, Heterocyclic aromatic compounds. Functional Group, Homologous Series</td><td>4</td></tr>
<tr><td rowspan="3">II</td><td colspan="2">Structure and bonding in Organic Molecules</td><td>9</td></tr>
<tr><td>3</td><td>Hybridization: sp3, sp2, sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide)</td><td>3</td></tr>
<tr><td>4</td><td>Overlap of atomic orbitals: Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules.</td><td>3</td></tr>
</table>

	5	Shapes of molecules; Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne)	3
III		**Functional Groups and Nomenclature**	**9**
	6	Classification, Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds: Alkanes, alkenes, alkynes	4
	7	Haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides)	3
	8	Nitro compounds, nitriles and amines and their cyclic analogues.	2
IV		**Introduction to Hydrocarbons**	**9**
	9	Chemistry of Aliphatic Hydrocarbons- Carbon - Carbon sigma bonds- Formation of alkane-	3
	10	Carbon - Carbon pi bonds- Formation of alkenes and alkynes, Aromatic Hydrocarbons- Aromaticity: Hückel's rule,	3
	11	Anti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples	3
V		**Natural Polymers-I**	**9**
	12	Introduction to polymer chemistry, Classification of polymers on the basis of origin, physical properties, structure and mode of polymerization	5
	13	Introduction of Natural Polymers-Advantage and disadvantage, comparison between natural and synthetic polymers, structure and vulcanization of natural rubber.	4

Introductory Organic Chemistry I Practical – 30 Hours

Module	Unit	Content	Hrs
I		**General Instructions**	**10**
	1	Readiness to follow Laboratory rules and regulations and cooperating with Lab instructors and staff for avoiding accidents	3
	2	Laboratory safety measures, develop safety skills by wearing lab coats, gloves and safety eye glasses wherever necessary (Necessity of FIRST AID and of keeping first Aid box in Lab)	3
	3	Procedures adopted in chemical splashes to skin, eyes, burns and	2

		electric shock, Instruction for emergency use of Fire extinguishers in Lab	
	4	Labels and warning symbols for Safe handling of Toxic and corrosive chemicals. Familiarization of MSDS of common laboratory chemicals	2
II		**Determination of Physical constants**	**10**
	5	Solubility of simple organic compounds	4
	6	Meting point of simple organic compounds	3
	7	Boiling point of simple organic compounds	3
III		**Thin layer Chromatography of simple organic compounds**	**10**
	8	Preparation of TLC plates	3
	9	Identification of solvent system	3
	10	Spotting of samples on TLC plates	2
	11	Visualisation of spots	2

References

1. A.Bahl and B.S.Bahl, Advanced Organic Chemistry, S.Chand& Company, New Delhi, 2022.
2. K.S.Tewari, N.K.Vishnoi and S.N.Mehrotra, A textbook of Organic Chemisty, Vikas
3. Publishing House (Pvt) Ltd., New Delhi, 2006.
4. S.C.Sharma and M.K.Jain, Modern Organic Chemistry, Vishal Publishing Company,
5. New Delhi, 2020.
6. I L Finar, "Organic Chemistry" Vol – 1&2, 5th Edition, Pearson Education, New Delhi, 2019.
7. Gowariker V.R., Viswanathan N.V. and Jayader Sreedhar, Polymer Science,
8. Wiley Eastern Ltd, New Delhi, 1986.
9. Paula Y Bruice, Organic Chemistry, 7th Ed, Pearson education, Asia, 2014.
10. 7.Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education,2009.
11. 8.Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson, 2012.
12. 9.Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of
13. Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the principles of structure and bonding in organic molecules, including the ability to identify different types of chemical bonds and molecular geometries.	**U**	**1,2**

CO-2	Demonstrate proficiency in drawing and interpreting molecular structures, including the representation of atoms, bonds, and functional groups.	**Ap**	**2,6**
CO-3	Recognize common functional groups present in organic compounds and apply systematic nomenclature rules to name and classify these compounds accurately.	**An**	**2,6**
CO-4	Explain the properties and reactivity patterns of hydrocarbons, including alkanes, alkenes, and alkynes, and predict their behaviour in various chemical reactions.	**U**	**1,2**
CO-5	Understand the classification of polymers, comparison between natural and synthetic polymers and identify the significance of natural polymers.	**U**	**5**
CO-6	Obey Lab safety instructions, develop qualities of punctuality, regularity and scientific attitude, outlook and scientific temper and develop skill in safe handling of chemicals, take precaution against accidents and follow safety measures	**Ap**	**4,6**
CO-7	Be able to explain how the melting point of organic compounds relates to their molecular structure and purity, allowing them to make predictions about melting behaviour and identify impurities.	**An**	**3,4,6**
CO-8	Develop thin layer chromatography of organic compounds	**C**	**3, 4,6**

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

Name of the Course: Introductory Organic 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	Understanding Basics of Organic Compounds.	**1,2/1,2**	**U**	**C**	**L**	

2	Understanding the Structure and Bonding of organic Molecule	**2/2,6**	**Ap**	**C**	**L**	
3	Identifying Functional Groups	**2/2,6**	**An**	**C**	**L**	
4	Explaining Hydrocarbon Properties.	**1/1,2**	**U**	**C**	**L**	
5.	Recognizing Natural Polymers	**1/5**	**U**	**C**	**L**	
6.	Obey Lab safety instructions, and develop skill in safe handling of chemicals, take precaution against accidents and follow safety measures	**2,6/4,6**	**Ap**	**P**		**P**
7.	Determine physical constants of organic compounds	**2,6/3,4,6**	**An**			**P**
8.	Develop TLC of organic compounds	**2,6/3,4,6**	**C**			**P**

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

Mapping of COs with PSOs and POs

	PSO 1	**PSO 2**	**PSO 3**	**PSO4**	**PS O5**	**PSO 6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	3	-	-	-	-	2	3	-	-	-	-
CO 2	-	3	-	-	-	3		3	-	-	-	-
CO 3	-	2	-	-	-	3		3	-	-	-	-

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

Discipline	POLYMER CHEMISTRY
Course Code	**UK1DSCPOC103**
Course Title	Basics of Physical 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. Understanding of fundamental knowledge in chemistry 2. Basic understanding of chemical reactions 3. Knowledge of basic physics principle
Course Summary	This course provides basic understanding of solid, liquid, gases and plasma at molecular level. Application of laws of thermodynamics to describe energy changes in chemical processes. Apply equilibrium principles to analyse physical and chemical systems. Understand about the thermal, mechanical and optical properties of polymer and their application in daily life. It also provides basic understanding about behaviour of matter and chemical reaction.

Detailed Syllabus

Module	Unit	Content	Hrs
I		**States of Matter**	**9**
	1	Introduction to states of matter: classification of matter; overview of solid, liquid, gases and plasma	1
	2	Properties of solids; crystal structures and lattice types	2
	3	Properties of Liquids: surface tension and capillary action, viscosity and flow behaviour	2
	4	Properties of gases: gas laws, Kinetic theory of gases	2
	5	Plasma: introduction, plasma properties and application	2
II		**Thermodynamics**	**9**
	6	Introduction to thermodynamics- Basic concept and definition: System, Surroundings, Types of Systems. Extensive and Intensive Properties. State and Path Functions.	1
	7	Types of Processes. Zeroth Law of Thermodynamics	1
	8	First Law of Thermodynamics and its Mathematical Formulation	1
	9	Definition of Internal Energy and Enthalpy. Heat Capacities at Constant Volume (Cv) and at Constant Pressure (Cp). Relationship between Cp and Cv	2
	10	Thermodynamic state variables: Definition of Internal Energy and Enthalpy. Heat Capacities at Constant Volume (Cv) and at Constant	2

		Pressure (Cp). Relationship between Cp and Cv and equation of state	
	11	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. (numerical problems)	2
III		**Concept of Equilibrium**	**9**
	12	Introduction to Equilibrium: Definition and significance of equilibrium, types of equilibrium, Equilibrium vs steady state	1
	13	Static Equilibrium: definition and characteristics, conditions for static equilibrium, Applications of equilibrium principle	2
	14	Chemical equilibrium: definition, equilibrium constant (Kp and Kc) and reaction quotient, Le Chatelier's principle and its application	3
	15	Dynamic equilibrium: definition and characteristics of dynamic equilibrium, examples of dynamic equilibrium in physical and chemical systems, rate of forward and reverse reactions in dynamic equilibrium	3
IV		**Photochemistry and Catalysis**	**9**
	16	Grothus-Draper, Beer- Lambert and Stark- Einstein laws	1
	17	Quantum yield, Reason for very low and very high quantum yield and examples	2
	18	Fluorescence and phosphorescence, chemiluminescence and photosensitization, Explanation and examples	2
	19	Catalysis- Theories of catalysis, Intermediate compound formation theory, steady state method	2
	20	Enzyme Catalysis-mechanism. Effect of temperature on enzyme catalysis.	2
V		**Introduction to Physical properties of Polymers**	**9**
	21	Introduction and history of polymeric materials, classification of polymers, nature of molecular interaction in polymers, Various structures of copolymers such as linear branched and cross-linked copolymers and their types.	1
	22	Crystal morphologies: Extended chain crystals, chain folding, lamellae, spherulites, crystallization and crystallinity on polymer properties, determination of crystallinity.	2
	23	Thermal properties- melting point and glass transition temperature. Measurement of glass transition temperature. Factors affecting glass transition temperature. Mechanical properties: tensile strength, impact strength, toughness, fatigue resistance	2

	24	Optical properties of polymers: transparency, opacity and colour, refractive index, application of optical polymers in displays, lenses and optical fibres	2
	25	Nature and structure of polymers: structure-property relationships, molecular weight of polymers, polydispersity, molecular weight distribution and determination of molecular weight by solution viscosity and end group analysis	2

Basics of Physical chemistry I Practical – 30 Hours

Module	Unit	**Content**	**Hrs**
I		**General Instructions**	**10**
	1	Readiness to follow Laboratory rules and regulations and cooperating with Lab instructors and staff for avoiding accidents	3
	2	Laboratory safety measures, develop safety skills by wearing lab coats, gloves and safety eye glasses wherever necessary (Necessity of FIRST AID and of keeping first Aid box in Lab)	3
	3	Procedures adopted in chemical splashes to skin, eyes, burns and electric shock, Instruction for emergency use of Fire extinguishers in Lab	2
	4	Labels and warning symbols for Safe handling of Toxic and corrosive chemicals. Familiarization of MSDS of common laboratory chemicals	2
II		**Physical characterisation of Polymers**	**20**
	6	Density measurement of polymers by floating method or pycnometer method	2
	7	Viscosity measurement of polymers	2
	8	Thermal analysis of polymers	2
	9	Mechanical testing of polymers	2
	10	Determination of Molecular weight of polymers	2
	11	Surface analysis of polymers	2
	12	Crystalline properties of polymers	2
	13	Electrical characterisation of polymers	2
	14	Rheological studies of polymers	2
	15	Dynamic mechanical analysis of polymers	2

References

1. Peter Atkins and Julio de Paula, Physical Chemistry Oxford University Press, 11th Edition, 2017
2. Stephen R. Turns, Thermodynamics: Concepts and Applications, Cambridge University Press, 1st Edition, 2014

3. Brian A. Wharton, Chemical Equilibrium and Analysis, Oxford University Press, 2nd Edition, 2014
4. Robert J. Young and Peter A. Lovell, Introduction to Polymers, CRC Press, 3rd Edition, 2011
5. Angelo Albini and Maurizio Fagnoni, Photochemistry Royal Society of Chemistry, 1st Edition, 2009
6. Roger Brown, Handbook of Polymer Testing: Physical Methods, 2nd Edition, 1999

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	ability to classify different states of matter and knowledge of the behaviour of solids, liquids, gases, and plasma under different conditions	**U, R**	**1,2**
CO-2	Understanding basic thermodynamic concepts, Proficiency in calculating heat, work, internal energy, and enthalpy changes in various systems	**R, U, Ap**	**1,2**
CO-3	Understanding of different types of equilibrium and application of equilibrium principles to solve problems in various fields	**R, U, Ap**	**1,2**
CO-4	understand about various photophysical laws, how to apply quantum yield, knowledge about catalysis and enzyme catalysis and insight into catalysis mechanism	**R, U, An**	**1,2**
CO-5	Knowledge of polymerization processes and molecular weight distribution, ability to analyse various properties of polymers	**R, U, An**	**1,2**
CO-6	Gain practical experience in various physical characterization techniques for polymers	**R,U,Ap,An**	**1,2,4,5**

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

Name of the Course: Basic 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)
CO-1	ability to classify different states of matter and knowledge of the behaviour of solids, liquids, gases, and plasma under different conditions	**1,2/1,2**	**U, R**	**C**	**L**	
CO-2	Understanding basic thermodynamic concepts, Proficiency in calculating heat, work, internal energy, and enthalpy changes in various systems	**1,2/1,2**	**R, U, Ap**	**C**	**L**	
CO-3	Understanding of different types of equilibrium and application of equilibrium principles to solve problems in various fields	**1,2/1,2**	**R, U, Ap**	**C**	**L**	
CO-4	understand about various photophysical laws, how to apply quantum yield, knowledge about catalysis and enzyme catalysis and insight into catalysis mechanism	**1,2/1,2**	**R, U, An**	**C**	**L**	
CO-5	Knowledge of polymerization processes and molecular weight distribution, ability to analyse various properties of polymers	**1,2/1,2**	**R, U, An**	**C**	**L**	
CO-6	Gain practical experience in various physical characterization techniques for polymers	**3,4,5,6/ 1,2,4,5**	**R,U,Ap, An**	**C, P**		**P**

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

Mapping of COs with PSOs and POs

	PS O1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	-	-	-	-	2	2	-	-	-	-
CO 2	2	2	-	-	-	-	2	2	-	-	-	-
CO 3	2	2	-	-	-	-	2	2	-	-	-	-
CO 4	2	2	=	-	-	-	2	2	-	-	-	-
CO 5	2	2	-	-	-	-	2	2	-	-	-	-
CO 6	2	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	✓	✓		✓
CO 6	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK1DSCPOC104**				
Course Title	Basics of 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. Basics of organic chemistry 2. Basic idea about polymers				
Course Summary	This course offers the study of classification of polymers, basic idea about structure, properties and characterisation techniques of polymers, basic polymerisation techniques, and applications of polymers in different fields. It also includes hands on experiments and project presentation.				

Detailed Syllabus

Module	**Unit**	**Content**	**Hrs**
I		**Introduction and classification of polymers**	**9**
	1	Polymers, monomers, examples. Polymerisation	2
	2	Classification of polymers- based on structure, source and behaviour.	3
	3	Properties of polymers-mechanical, thermal, chemical resistance and electrical properties	2
	4	Structure of polymers-linear, branched and cross-linked polymers Tacticity of polymers.	2
II		**Characterisation of Polymers**	**9**
	5	Preliminary analysis: solubility, flame test, Lassaign's test, heating test and melting point test (LDPE and HDPE).	2
	6	Characterisation of polymers – by molecular weight determination-light scattering method, viscosity method, Gel permeation chromatography	3
	7	Characterisation by mechanical testing-Tensile testing, impact testing, flexural testing, compression testing	2

	8	Characterisation by environmental testing-Biodegradation testing-composting test, soil burial test, microbial degradation assessment.	2
III		**Polymerization Techniques**	**9**
	9	Polymerisation techniques-concept. steps in polymerisation-initiation, propagation and termination	3
	10	Free radical polymerisation-Free radical initiator, initiation, propagation. and termination-poly ethylene, PVC	2
	11	Anionic polymerisation-anionic initiator, initiation, propagation and termination-poly butadiene	1
	12	Cationic polymerisation methods-cationic initiators-initiation, propagation and termination -Poly styrene. Co-ordination polymerisation-metal catalyst, Zeigler -Natta Catalyst-poly ethylene, poly propylene	3
IV		**Commercial Polymers**	**9**
	13	Commercial importance of polymers-Introduction	1
	14	Fibres-Nylon-6 and nylon-6,6, Poly ester -Properties, monomers and commercial importance	2
	15	Thermosets-Bakelite, melamine -formaldehyde resin - Properties, monomers and commercial importance	2
	16	Thermoplastics-Definition-PVC, PET Polyethylene, polypropylene and polystyrene - -Monomers, properties and commercial importance	4
	17		
V		**Applications of polymers**	**9**
	18	Polymers in construction materials-composites, water proofing membranes, sealants,	2
	19	Polymers in biomedical implants-ophthalmic, dental, cardiovascular and orthopaedic implants-	2
	20	Polymers in packaging-biodegradable and compostable packaging, PET bottles, poly ethylene film, Polystyrene foams	2
	21	Polymers in aerospace materials-composites, adhesives and sealents,3Dprinting, thermal protection system	3

Basics of Polymer Chemistry Practical -30 Hrs

Module	Unit	Content	Hrs
		Preliminary analysis of Polymers	**10**
I	1	Hands on practise with Solubility test of following polymers in different solvents like water, acetone and chloroform. 1.HDPE 2.LDPE 3.Nylon 4.PVAL	4

	2	Hands on practice with Lassign's Test for standard polymer samples	4
	3	Melting point test to distinguish HDPE and LDPE	2
		: Group Project presentation on the topic Applications of polymers	**20**
II	4	Introduction-overview of polymer, structure, properties and application, forming project groups and selecting application.	4
	5	Literature review and project planning-research on selected project and gathering information from reputed source, developing project outline and assigning responsibilities within each group.	4
	6	preparation of Project work and presentation-group work sessions-content refining, making slides, practising delivery and receiving feedback.	6
	7	Group project presentations- group presentation to the class &A sessions after each presentation. Peer evaluations forms for assessing presentation quality and content.	6

References

1. Malcon P. Steves, Polymer chemistry-An introduction, Oxford University Press, 3rd edition, 1999.
2. Charles E. Carraher Jr, Introduction to Polymer Chemistry, CRC Press, Boca Raton,4th edition,2017.
3. Robert J. Young and Peter A. Lovell, Introduction to polymers, CRC Press, Boca Raton,3rd edition,2011
4. Andrew J Peacock, Allison R Calhoun, Polymer Chemistry: Properties and Applications, Hanser Gardner Publication,2006.
5. Joel R Fried, Polymer Science and Technology, Prentice Hall,3rd edition,2014.
6. Dan Campbell, Richard A, Pethrick, Jim R White, Polymer Characterization, CRC Press, London,2nd edition,2000.
7. Roger Brown edited Hand book of Polymer Testing, CRC Press, Boca Raton,2014

Course Outcomes

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

CO-1	Explaining fundamental concepts related to structure, properties and classification of polymers	**U**	**PSO 1**
CO-2	A comprehensive explanation of different commercial polymers, their properties, applications, environmental impacts. and characterisation techniques of polymers	**U,Ap**	**PSO1,8**
CO3	Updating with latest trends and emerging applications of polymers such as 3Dprinting with polymers, nanocomposites etc and explore the wide range of industries that rely on commercial polymers	**U,Ap**	**PSO1,6**
CO4	Develop skill to carry out solubility test and Lassign's test for different polymers and enhance communication skill through presentation, reports and discussions and to collaborate effectively in team projects related to Applications of polymers	**U.An**	**PSO1,3,4**
CO5	Explaining different polymerisation techniques	**U**	**PSO 1**

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

Name of the Course: Basics 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	Explaining fundamental concepts related to structure, properties and classification of polymers	**1/1**	**U**	**C**	**L**	
2	A comprehensive explanation of different commercial polymers, their properties, applications, environmental impacts. and	**2/1,8**	**U, Ap**	**C**	**L**	

	characterisation techniques of polymers					
3.	Updating with latest trends and emerging applications of polymers such as 3Dprinting with polymers, nanocomposites etc and explore the wide range of industries that rely on commercial polymers	**1/1,6**	**U, Ap**	**C**	**L**	
4	Develop skill to carry out solubility test and lassign's test for different polymers and enhance communication skill through presentation, reports and discussions and to collaborate effectively in team projects related to Applications of polymers	**1,4,7/1, 3,4,5**	**U, An**	**C**		**P**
5	Explaining different polymerisation techniques	**1/1**	**U**	**C**	**L**	

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

Mapping of COs with PSOs and POs

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

<table>
<tr><td>Discipline</td><td colspan="5">POLYMER CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK1DSCPOC105</td></tr>
<tr><td>Course Title</td><td colspan="5">Introduction to Polymers</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">1</td></tr>
<tr><td>Academic Level</td><td colspan="5">100 - 199</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. Familiarity with the concept of monomers and polymers.
2. Basic understanding of different types of materials (natural and synthetic)
3. Fundamental Knowledge of environmental science principles.
4.Awareness of common applications of polymers in industries such as packaging, automotive, and construction.</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course offers a comprehensive introduction to the fundamental concepts of polymer science and its wide-ranging practical implications. Students will delve into the chemical structure of polymers, study different methods of polymerization including addition and condensation, learn about various manufacturing techniques and discover the diverse industrial applications of polymers in areas such as packaging, automotive, construction, textiles, and healthcare.</td></tr>
</table>

Detailed syllabus.

<table>
<tr><th>Module</th><th>Unit</th><th>Content</th><th>Hrs</th><th>CO No.</th></tr>
<tr><td rowspan="5">I</td><td colspan="2">Essentials of Polymer Chemistry</td><td>9</td><td></td></tr>
<tr><td>1</td><td>Brief history of macromolecular science, general characteristics of polymers in comparison with common organic compounds.</td><td>2</td><td>1</td></tr>
<tr><td>2</td><td>Average Molecular Weight, Molecular weight, Distribution & Poly dispersity Index.</td><td>2</td><td>1</td></tr>
<tr><td>3</td><td>Structure of polymers, amorphous, semi-crystalline and crystalline states in polymers, glass transition, melting and crystallization temperature.</td><td>3</td><td>1</td></tr>
<tr><td>4</td><td>Effect of structure on the chemical, mechanical, electrical and optical properties of polymers.</td><td>2</td><td>1</td></tr>
<tr><td rowspan="3">II</td><td colspan="2">Commercial Classification of Polymers</td><td>9</td><td></td></tr>
<tr><td>5</td><td>Addition- condensation, Chain/step growth polymerization, organic-inorganic, natural- synthetic, thermoplastic – thermosetting, polar- nonpolar polymers with suitable examples, based on applications</td><td>3</td><td>2</td></tr>
<tr><td>6</td><td>Fibers, foams, adhesives and elastomers, based on performance – commodity and engineering polymers.</td><td>2</td><td>2</td></tr>
</table>

	7	Homopolymers, co-polymers, linear polymers, branched polymers, cross linked or three-dimensional polymers, block and graft co-polymers, linear, branched, crosslinked types of polymers.	3	2
	8	Functional Polymers, Polymer Blends and Alloys	1	2
III		**Methods of Polymerization**	**9**	
	9	Bulk, solution, precipitation, suspension, emulsion, inverse emulsion, melt polycondensation, solution polycondensation.	3	3
	10	Interfacial polymerization, solid state polymerization and gas phase polymerization.	2	3
	11	Batch, semi batch and continuous process, merits and limitations of each process.	2	3
	12	Comparison of various polymerization processes with suitable commercial examples.	2	3
IV		**Polymer Manufacturing Techniques**	**9**	
	13	Extrusion, Calendaring.	3	4
	14	Injection Moulding, Injection Blow moulding.	2	4
	15	Blow Moulding, Transfer Moulding.	2	4
	16	Compression Moulding Rotational Moulding.	2	4
V		**Industrial applications of Polymers**	**9**	
	17	Polymers for high temperature applications- Fluoro polymers, Aromatic polymers, Heterocyclic polymers, Polymers as building Materials	3	5
	18	General purpose Polymers- Polyamides, EVA, EPDM, UHMW-HDPE, polycetals	3	5
	19	High performance polymers- Aromatic ethers, aromatic thioethers, polysulfones, polyether sulfones	3	5

Introduction to Polymers Practical – 30 Hour

Module	Unit	Content	Hrs
I		**Preparation of Polymers**	**24**
	1	Preparation of alkyd resin from vegetable oil & by testing its coating properties.	2
	2	Preparation of polymer-fiber composite & study its properties.	2
	3	Preparation of biodegradable polymer from banana peel.	2
	4	Preparation of Urea formaldehyde resin	3
	5	Preparation of Phenol formaldehyde resin – novolak and resol Preparation of Melamine formaldehyde resin	3
	6	Preparation of alkyd resin Preparation of epoxy resin	3
	7	Preparation of varnish, distemper, primer, undercoat and topcoat Preparation of polysulphide resin.	3

	8	Preparation of Nylon-6,6 / -6,10 salt using HMDA- adipic acid/Sebasic acid.	3
	9	Preparation of P.F. ion exchange resin	3
II		**Qualitative analysis of plastic and rubber**	**6**
	9	Polyethylene, Polyethylene Terephthalate, Polyvinyl Chloride, Polystyrene, Polypropylene etc	3
	10	Natural Rubber, Styrene-Butadiene Rubber, Butyl Rubber, Neoprene etc	3

References

1. Malcon P. Steves, Polymer chemistry-An introduction, 3rd edition, Oxford University Press,
2. 1999.
3. F. W. Billmayer, Text book of Polymer Science, 3rd edition, John Wiley & Sons, 1984.
4. V. R. Gowariker, N. V. Viswanathan &J. Sreedhar, Polymer Science, New Age International Publishers, 2005.
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6. Edition, 2006.
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8. G. Odian, Principles of polymerization, 3rd edition, John Wiley & Sons, 2004.
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10. Distributors, New Delhi, 1993.
11. V. K. Ahluwalia & A. Misra, Polymer Science-A Text Book, Ane Books, India, New Delhi,
12. 2016.
13. J. R. Fried, Polymer Science & Technology, Prentice Hall of India Pvt. Ltd, New Delhi, 2014.
14. 10.Fred J Davis, Polymer Chemistry-a Practical Approach, Oxford university press,2004

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the basic concepts and various structure of polymers.	**U**	**1**
CO-2	Gain a comprehensive understanding of polymer chemistry, including various types of polymers, their synthesis methods, structural characteristics, and applications in different industries.	**A**	**1 & 2**
CO-3	Develop a thorough understanding of polymerization processes, including their mechanisms, applications, and the advantages and limitations of different	**R, E**	**8&5**

	synthesis methods.		
CO-4	Develop a deep understanding of polymer processing techniques, including extrusion, moulding, and shaping methods, enabling efficient production and customization of polymer products.	**Ap**	**5**
CO-5	Gain expertise in selecting and utilizing polymers for various applications, including high-temperature environments, structural applications, and high-performance requirements, enabling effective material design and engineering solutions.	**An**	**5,7**
CO-6	Acquire hands-on experience in polymer preparation and qualitative analysis of plastics and rubbers, enhancing understanding of synthesis methods and material properties for practical applications.	**U**	**4**

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

Name of the Course: Introduction to Polymers Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic concepts and various structure of polymers.	**1/1**	**U**	**F**	**L**	
CO-2	Gain a comprehensive understanding of polymer chemistry, including various types of polymers, their synthesis methods, structural characteristics, and applications in different industries.	**3/1 & 2**	**A**	**C**	**L**	
CO-3	Develop a thorough understanding of polymerization processes, including their mechanisms, applications, and the advantages and limitations of different synthesis methods.	**2/8&5**	**R, E**	**F**	**L**	

CO-4	Develop a deep understanding of polymer processing techniques, including extrusion, moulding, and shaping methods, enabling efficient production and customization of polymer products.	**2/5**	**Ap**	**F**	**L**	
CO-5	Gain expertise in selecting and utilizing polymers for various applications, including high-temperature environments, structural applications, and high-performance requirements, enabling effective material design and engineering solutions.	**3/5,7**	**An**	**C**	**L**	
CO-6	Acquire hands-on experience in polymer preparation and qualitative analysis of plastics and rubbers, enhancing understanding of synthesis methods and material properties for practical applications.	**6/4**	**U**	**P**		**p**

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

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO 4	PSO5	PSO 7	PSO8	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	3	-	-	-	-	-	-	3	-	-	-
CO 3	-	-	-	2	-	-	-	2	-	-	-	-
CO 4	-	-	-	3	-	-	-	3	-	-	-	-
CO 5	-	-	-	2	3	-	-	-	-	-	-	-
CO 6	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK1DSCPOC106**				
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. An understanding of general chemistry concepts. 2. Basic understanding of matter. 3. Fundamental Knowledge of environmental science principles. 4. Basic Knowledge of cells, DNA, proteins, and basic biological processes.				
Course Summary	This course provides a comprehensive understanding of environmental chemistry, nanoscience basics, green chemistry principles, and biomolecule concepts. Students will learn about pollutants' impact, nanomaterial properties, eco-friendly chemical processes, and biological molecule structures.				

Detailed Syllabus

Module	Unit	Content	Hrs	CO No.
I		**Environmental Chemistry**	**9**	
	1	Nature of environmental threats and role of chemistry.	2	1
	2	Greenhouse effect, ozone layer and its depletion.	2	1
	3	Water pollution: Various factors affecting purity of water, sewage water, industrial waste, agricultural pollution such as pesticides, fertilizers, detergents.	3	1
	4	Dissolved oxygen-BOD, COD.	2	1
II		**Basics of Nanoscience**	**9**	
	5	Terminology. Scales of nanosystems. Different types of nanoparticles.	2	2
	6	Applications of nanoparticles in biology and medicine – biological labels, drug and gene delivery, tissue engineering, tumour destruction.	3	2
	7	Other applications of nanoparticles – electronics, paints, food packaging.	3	2
	8	Toxicology of nanoparticles.	1	2
III		**Green Chemistry**	**9**	
	9	Chemical Pollution and its after effects, conventional waste disposal techniques & its Limitations.	2	3
	10	History of disasters like Chernobyl Disaster, Bhopal gas tragedy.	2	3
	11	Introduction to green chemistry.	2	3

	12	Twelve principles of green chemistry, Atom economy- Examples.	3	3
IV		**Introduction to Biomolecules**	**9**	
	13	Overview of biomolecules, their importance in living organisms, and basic concepts.	2	4
	14	Structure, function, classification, biochemical properties, and examples of proteins in biological systems.	3	4
	15	Structure of DNA and RNA, replication, transcription, translation, and genetic code.	2	4
	16	Enzymes, Characteristics, Mechanism of enzyme catalysis.	2	4
V		**Biopolymers**	**9**	
	17	Overview of biopolymers, their significance in biological systems, and applications in different industries.	2	5
	18	Structure, properties, and functions of proteins as biopolymer and applications in biotechnology.	3	5
	19	Exploration of natural rubber, latex, and other biopolymeric materials found in nature, their properties and industrial applications.	2	5
	20	Discussion on biodegradable biopolymers and their role in addressing plastic pollution and sustainability challenges.	2	5

General Chemistry I   Practical – 30 Hours

Module	Unit	Content	Hrs
I		**Water quality analysis**	**21**
	1	Determination of PH and Electrical Conductivity of water	2
	2	Determination of Alkalinity.	2
	3	Determination of Hardness (Total, Permanent & Temporary)	2
	4	Determination of calcium.	3
	5	Determination of Magnesium.	3
	6	Determination of Carbonates & Bi-carbonates.	3
	7	Determination of Chemical Oxygen demand (C.O.D.)	3
	8	Determination of Biochemical Oxygen Demand (B.O.D.)	3
II	**Estimation of hardness**		**9**
	9	Estimation of total hardness of water	3
	10	Estimation of permanent hardness of water	3
	11	Estimation of temporary hardness of water	3

References

1. A. K. De, Environmental Chemistry, New Age International (P) Ltd. New Delhi, 8th Edn, 2016.
2. A. K. Ahluwalia, Environmental Chemistry, Ane Books, India, New Delhi, 2008.
3. T. Pradeep, Nano: The Essentials, Mc Graw Hill Publishing Company, New Delhi, 2007.
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5. Anastas. P.T; Warner, J.C, “Green Chemistry; Theory and Practice”, Oxford University Press; Oxford, U.K., 1998.

6. Lancaster. M. Green Chemistry; An introductory text, Royal society of chemistry, Cambridge, UK, 2003.
7. Lehninger, Principles of Biochemistry: 6th edition 2014.
8. Garret and Grisham Biochemistry, 2016.
9. Werner Stumm and James J. Morgan, Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters, Wiley inter-science, 3rd Ed., 1995.
10. Bruce Jefferson, Simon Parsons, John Piggot and Rupert, Practical Hand Book of Water Analysis Press, Second Edition,2013

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Appraise the current development in Chemistry and contribution of chemistry for sustainable development	E	8
CO-2	Define nanoscience terminology, discuss nanoparticle types and their applications in biology, medicine, electronics, paints, and food packaging.	U,Ap	1
CO-3	Understand the principles of green chemistry, including waste disposal limitations, historical environmental disasters, and the twelve principles of green chemistry with examples like atom economy.	R	8
CO-4	Describe biomolecules' structures, functions, classifications, and their roles in living organisms, including proteins, DNA, RNA, enzymes, and their mechanisms.	Ap	8
CO-5	Develop curiosity and scientific attitude towards the application of polymer chemistry in daily life	C	7
CO-6	Develop skills in water quality assessment and be capable of identifying and quantifying different components that impact water purity, paving the way for informed environmental management and remediation strategies.	U	3

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)
CO-1	Appraise the current development in Chemistry and contribution of chemistry for sustainable development.	**1/8**	**E**	**F**	**L**	
CO-2	Define nanoscience terminology, discuss nanoparticle types and their applications in biology, medicine, electronics, paints, and food packaging.	**2/1**	**U, Ap**	**F**	**L**	
CO-3	Understand the principles of green chemistry, including waste disposal limitations, historical environmental disasters, and the twelve principles of green chemistry with examples like atom economy.	**1/8**	**R**	**C**	**L**	
CO-4	Describe biomolecules' structures, functions, classifications, and their roles in living organisms, including proteins, DNA, RNA, enzymes, and their mechanisms.	**3/8**	**Ap**	**F**	**L**	
CO-5	Develop curiosity and scientific attitude towards the application of polymer chemistry in daily life	**2/7**	**C**	**F**	**L**	
CO-6	Develop skills in water quality assessment and be capable of identifying and quantifying different components that impact water purity, paving the way for informed environmental management and remediation strategies.	**6/3**	**U**	**F**		**P**

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

Mapping of COs with PSOs and POs

	PSO1	PSO3	PSO7	PSO8	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	3	2	-	-	-	-	-
CO 2	2	-	-	-	-	2	-	-	-	-
CO 3	-	-	-	3	1	-	-	-	-	-
CO 4	-	-	-	2	-	-	3	-	-	-
CO 5	-	-	3	-	-	1	-	-	-	-
CO 6	-	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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK1MDCPOC101**				
Course Title	Introduction to Polymer 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.General introduction to polymers and polymerisation 2. Introduction to inorganic and smart polymers.				
Course Summary	Includes the fundamental principles of polymer chemistry, including classification of polymers based on origin, structure, and synthesis methods. Analysing the physical and chemical properties of natural and synthetic rubbers, including reinforcement technologies, and applications in various industries. Also includes brief introduction about Inorganic and Smart polymers.				

Detailed syllabus

Module	Unit	Content	Hrs
I		**Basic Principles of Polymers**	**9**
	1	General introduction to polymers: Macro molecules, Oligomers, Polymers, Degree of Polymerisation, Functionality, Nomenclature of Polymers.	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	Natural polymers- Cellulose, Silk, Gums and Resins,	2
	5	Concept of molecular weight – Number average and Weight average only.	2
II		**Types of Polymerisation**	**9**
	6	Chemistry and mechanism of Polymerization – Factors affecting on polymerization	1
	7	Addition polymerization (free radical, ionic and co-ordination polymerizations)	2
	8	Condensation polymerization, Ring opening polymerization	2
	9	Redox Polymerization, Living radical polymerization	2
	10	Co-polymerization, Co-poly condensation	2
III		**Commercial Polymers**	**9**

	11	Commercially important polymers and their applications: Poly ethylene, Polypropylene	2
	12	Poly styrene, Poly esters, Polyvinyl Chloride (PVC).	2
	13	Polymethylmethacrylate Bakelite, Natural Rubber	2
	14	Nylon-6, Nylon-66, Melamine, Terylene	2
	15	Numbering of Plastics(Plastic identification code)	1
IV	**Rubber Chemistry and Technology**		**9**
	16	Natural and Synthetic rubber: Historical review, physical and chemical properties of natural rubber.	1
	17	Manufacture, physical properties and applications of synthetic rubbers such as SBR, Nitrile, Butyl Rubber	2
	18	EPDM, Neoprene. Vulcanisation of Rubber	2
	19	Rubber processing- Miling, Mixing, Extrusion, Calendering, Molding and Curing (Explanation only),	2
	20	Rubber reinforcement technologies: Brief introduction, Role of fillers and reinforcements – carbon black.	2
V	**Inorganic Polymers and Smart polymers**		**9**
	21	Boron polymers: boron –nitrogen, boron-phosphorous, boron-hydrogen polymers.	2
	22	Silicon polymers, Natural and synthetic coordination polymers.	2
	23	Introduction to Smart Polymers- Examples with applications.	1
	24	Chemical responding smart polymers, Temperature responding smart polymers.	2
	25	pH responding smart polymers, Light responding smart polymers	2

References

1. Fred W. Billmeyer, ‘Textbook of Polymer Science’, Wiley Interscience publications, 3rd edition,2007.
2. V.R. Gowariker,N V Viswanathan, Jayadev Sreedhar, ‘Polymer Science’, New Age International Pvt Ltd,4th edition, 2021.
3. Paul J. Flory, ‘Principles of Polymer Chemistry’, Asian Books Private Ltd, 2006.
4. P. Ghosh, ‘Polymer Science and Technology of Plastic and Rubber’, Tata McGraw Hill,3rd edition, 2011.
5. Martin and Smith,’Handbook of Rubber Technology’, CBS Publisher,2007.
6. Malcolm P. Stevens, ‘Polymer Chemistry’, Oxford University Press, 3rd edition,1998.
7. James E. Mark, Harry R. Allcock, and Robert West, ‘Inorganic Polymers’ ,Oxford University press, 2nd edition,2005.
8. Maria Rosa Aguilar and Julio San Roman,’ Smart Polymers and their Applications’, Elsevier Publications,2nd edition,2019.

Course Outcomes

CO	Upon completion of the course the graduate will be	Cognitive	PSO

No.	able to	Level	addressed
CO-1	Understand the basic concepts of polymer chemistry, to study the structure of monomers, functionality, classification and synthesis of polymers. Also get an idea about natural polymers and molecular weight of polymers.	**R, U**	**1**
CO-2	Realize the different factors affecting the polymerisation reaction and identify the mechanism behind different polymerization methods like Addition polymerisation, Condensation polymerisation, Ring opening polymerisation, Redox polymerisation etc	**U**	**5**
CO-3	The course would also enable the students to aware of the commercial applications of polymers in real world, its structure properties and relationship.	**R,U**	**5**
CO-4	Become fully aware of the Natural rubber and synthetic rubbers and its processing.	**U**	**1**
CO-5	Get an awareness about the versatility and untapped potential of inorganic and smart polymeric materials which are the most exciting interfaces of chemistry and biology	**R,U**	**5**

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

Name of the Course: Introduction to Polymers Credits: 3:0:0 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic concepts of polymer chemistry, to study the structure of monomers, functionality, classification and synthesis of polymers. Also get an idea about natural polymers and molecular weight of polymers.	**1/1**	**U**	**F, C**	**L**	
CO-2	Realize the different factors affecting	**1/5**	**U**	**P**	**L**	

	the polymerisation reaction and identify the mechanism behind different polymerization methods like Addition polymerisation, Condensation polymerisation, Ring opening polymerisation, Redox polymerisation etc					
CO-3	The course would also enable the students to aware of the commercial applications of polymers in real world, its structure properties and relationship.	**2/5**	**R,U**	**F**	**L**	
CO-4	Become fully aware of the Natural rubber and synthetic rubbers and its processing.	**1/1**	**R, U**	**F**	**L**	
CO-5	Get an awareness about the versatility and untapped potential of inorganic and smart polymeric materials which are the most exciting interfaces of chemistry and biology	**2/5**	**U**	**F**	**L**	

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

Mapping of Cos with PSOs and Pos :

	PSO1	**PSO5**	**PO1**	**PO2**	**PO3**
CO 1	3	-	3	-	-
CO 2	-	3	3	-	-
CO 3	-	3	-	2	-
CO 4	3	-	3	-	-
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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK1MDCPOC102**				
Course Title	Introduction to 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. Prelliminary idea of chemistry				
Course Summary	Includes a brief introduction of environmental components, different types of pollution and some major environmental disasters.				

Detailed syllabus

Module	Unit	Content	Hrs
I		**Basic Concepts of Environment**	**9**
	1	Types of Environments - Biotic and Abiotic, Environmental segments- Lithosphere, Hydrosphere, Biosphere and Atmosphere.	2
	2	Layers of Lithosphere, Layers of Atmosphere-Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.	2
	3	Meaning of Ecology - Structure and Function of Ecosystem- Producers, Consumers, Decomposers.	3
	4	Ecological Succession-Food chain and ecological pyramids.	2
II		**Air Pollution**	**9**
	5	Pollution, Pollutants and its Classification.	2
	6	Air Pollution - Types of Gaseous Air pollutants-CO, CO_2, NO, NO_2, SO_2, SO_3, Smog - Sources and Effects.	3
	7	Consequences of Air pollution - Global warming, Greenhouse effect, Acid rain and Importance of Ozone layer.	4
III		**Water Pollution**	**9**
	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
IV		**Soil Pollution**	**9**
	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
V		**Environmental disasters**	**9**
	14	Definition and types of disasters – Natural and Man made.	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

References

1. A. K. De, “Environmental Chemistry”, New Age Publisher International Pvt Ltd, 8th edition, 2016.
2. H. M. Saxena, “Environmental Geography”, Rawat Pubns, 3rd edition,2017.
3. Gary W. Vanloon, Stephan J. Duffy, “Environmental Chemistry – a global perspective”,OUP Oxford,4th edition,2017.
4. P. K. Gupta, “Methods in Environmental Analysis Water, Soil and Air”,Agrobios,2nd edition,2018.
5. V.K Ahluwalia, “Environmental Chemistry”,ANE Books,2nd edition,2013.
6. G. S. Sodhi, “Fundamental Concepts of Environmental Chemistry”,Alpha Science International Ltd,3rd edition,2008.
7. V Subramanian, A Text Book of Environmental Chemistry, Wiley India Pvt Ltd, Zero edition, 2020.
8. C Baird, M Cann, Environmental Chemistry, W.H. Freeman and Co Ltd,5th edition, 2012.

Course Outcomes

CO 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**	**1**
CO-2	Identify, Realise and enlist the causes of air pollution	**R, U**	**8**
CO-3	Understand the qualities of water, Identify the causes and effects of water pollution and acquire knowledge of waste water treatment	**R, U**	**8**
CO-4	To get a basic knowledge of Soil Pollution	**U**	**8**

CO-5	Review major environmental disasters	**R**	**8**

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)
CO-1	Understand the structure and composition of the atmosphere	**1/1**	**U**	**F**	**L**	
CO-2	Identify, Realise and enlist the causes of air pollution	**1/8**	**R, U**	**F**	**L**	
CO-3	Understand the qualities of water, Identify the causes and effects of water pollution and acquire knowledge of waste water treatment	**2/8**	**R, U**	**F**	**L**	
CO-4	To get a basic knowledge of Soil Pollution	**1/8**	**U**	**F**	**L**	
CO-5	Review major environmental disasters	**1/8**	**R**	**F**	**L**	

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

Mapping of COs with PSOs and POs

	PSO1	PSO8	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	2					
CO 2	-	3	3					
CO 3	-	3		3				
CO 4	-	3	3					
CO 5	-	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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2DSCPOC101**				
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	A basic idea of types of chemical bonding in chemistry An understanding of the periodic table. Principles of Analytical Chemistry Basic knowledge in polymers				
Course Summary	This course provides an information about chemical bonds and concepts, Various types of bonding and their theories, periodic properties. It is also envisioned to provide concepts in redox titration, solvent extraction and chromatographic techniques. Course also discusses lab safety procedures and brief introduction and applications of natural and synthetic polymers.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**Chemical Bonding I**	**9**
	1	Types of bonds, General properties of ionically and covalent bonded compounds. Ionic bond- Lattice energy of ionic compounds-Born Haber Cycle. Partial covalent character of ionic bond- Fajan's rule.	1
	2	Covalent bond - Lewis theory, Sidgwick - Powell theory, VSEPR theory	2
	3	V. B. Theory (qualitative idea, hydrogen as example)	1
	4	Hybridisation - Explanation of structures of molecules such as SF_4, ClF_3, IF_7, XeF_4 & XeF_6.	2
	5	Rules of LCAO, M.O. Configuration of H_2^+, He^{2+}, Li^{2+}, C_2, N_2, O_2, O_2^- , F_2, NO bond order. M. O. treatment involving delocalized π bonding resonance.	3
II		**Chemical Bonding II**	**9**

	6	Sigma and pi bonds, Extent of d orbital participation in molecular bonding. M. O. Method - s – p, p– p, p-d, d-d, and non–bonding combinations of orbitals	3
	7	Types of bonding- ionic bond- ionic lattice energy of ionic compounds, Bond – Lande equation, Born – Haber cycle, Solvation, Energy and solubility of ionic solids, Covalent character of ionic bond, Fajan's rules.	3
	8	Polarity of covalent bond, Dipole moment, Percentage of ionic character and molecular structure.	1
	9	Metallic Bonding – Qualitative Idea of bonding in metals, Free electron theory, V B Theory, Band theory.	2
III	**Analytical Principle II**		**9**
	10	Theory of Redox titration: Titration of Fe^{2+} with $KMnO_4$ and $K_2Cr_2O_7$ and theory of redox indicators.	2
	11	Chromatography - Elementary idea about Adsorption chromatography, Column chromatography, Thin layer chromatography, Partition chromatography, Ion exchange chromatography and Gas chromatographic methods.	4
	12	Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction.	2
	13	Concept of sampling. Importance of accuracy, Precision and Sources of error in analytical measurements, Significant figures. Mean and Standard deviation, Confidence intervals.	1
IV	**Laboratory Safety**		**9**
	14	Introduction to lab safety, Personal hygiene, Common lab wearables, Gas mask types (basic idea), Regulatory requirement labels, Material safety, Hazard Warning information and Symbols, Labelling of Chemicals, Hazard control.	3
	15	Fuels, Propellants, Explosives, Flammable solvents, Metal hydrides.	1
	16	Hazards due to chemicals- Strong acids, Strong bases, Irritants, Halogen chromates, Toxic solids, Toxic gases, Toxic liquids, Carcinogenic substances, Pyrophorics.	2
	17	Material safety data sheet, Toxicological information, LD_{50} and LC_{50} values, Industrial disasters, Bhopal gas tragedy.	2

	18	Emergency procedures in Chemical splashes to skin and eyes, burns and electric shock. First aid, Emergency preparedness and responses.	1
V	**Applications of Polymers**		**9**
	19	General characteristics and applications of polymers such as Polythene (LDPE and HDPE), polypropylene, PVC, Polystyrene, PET, Teflon, Terrylene, Nylons (Nylon 6, Nylon 66 & Kevlar), PMMA and Bakelite.	5
	20	Significance, classifications, properties and applications of biopolymers and natural polymers such as Starch, cellulose, chitosan, gelatine, protein, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose.	3
	21	Polymers in Biomedical applications and their Importance - hydrogel, fibres, bio-ceramics and bio-membrane.	1

Fundamentals of ChemistryII Practical – 30 Hours

Module	Unit	Content	Hrs
I	**Redox titration**		**30**
		Permanganometry	
	1	Standardisation of Potassium permanganate using A.R Oxalic acid/Mohr's salt	2
	2	Estimation of Ferrous iron	2
	3	Estimation of Oxalic acid	2
	4	Estimation of Hydrogen peroxide	3
	5	Estimation of Calcium	3
	6	Estimation of Nitrite	3
	7	Estimation of MnO_2 in pyrolusite	3
II		**Dichrometry**	
	8	Determination of Ferrous iron using internal & external indicator	3
	9	Determination of Ferric iron after reduction with $SnCl_2$.	3
		Ceremetry	
	10	Standardization of ceric ammonium sulphate with Mohr's salt.	3
	11	Determination of oxalic acid using ceric ammonium sulphate	3

Reference

1. B. R. Puri, L. R, Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, New Delhi, Edn. 2010.
2. M. C. Day and J Selbin, Theoretical Inorganic Chemistry,2nd Edn. Reinhold Book Corp, 1970.

3. S. Prakash, G. D.Tuli, S. K. Basu, R. D. Madan, Advanced Inorganic Chemistry, Vol. 1, S Chand publishers, 2000.
4. Manas Chanda, Atomic Structure and Chemical bonding in Molecular Spectroscopy, Tata McGraw Hill, 2011.
5. D. C. Harris, Qualitative Chemical Analysis, 5th Edn., W.H. Freeman & Co. New York, 1995.
6. M. N. Vyas, Safety and Hazards Management In Chemical Industries, Atlantic Publishers & Distributors Pvt Ltd, 2013.
7. Gowri Sankar Misra, Introductory Polymer Chemistry, New Age International, New Delhi, 1993.
8. Malcon P. Steves, Polymer chemistry - An introduction, 3rd edition, Oxford University Press, 1999.
9. A. O. Thomas and Mani, Text Book of Practical Chemistry Scientific Publication, 4th Revised Edition, 1976.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Define various types of bonds, bonding theories, hybridization and its main features.	**U**	**1**
CO-2	Discuss about sigma and pi bonds, M O treatment, dipole moment, ionic character and metallic bonding and secondary forces in nature.	**U**	**2**
CO-3	Discuss various qualitative and quantitative analytical principles and procedures.	**R, Ap**	**3**
CO-4	Discusses lab safety instructions, develop scientific attitude and emergency procedures regarding personal safety.	**U, Ap**	**3**
CO-5	Discuss about applications of different types of natural and synthetic polymers.	**U**	**P1**

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)
CO-1	Define various types of bonds, bonding	**1/1**	**U**	**C**	**L**	

	theories, hybridization and its main features.					
CO-2	Discuss about sigma and pi bonds, M O treatment, dipole moment, ionic character and metallic bonding and secondary forces in nature.	**6/2**	**U**	**C**	**L**	
CO-3	Discuss various qualitative and quantitative analytical principles and procedures.	**3/3**	**R, Ap**	**C**	**L**	**P**
CO-4	Discusses lab safety instructions, develop scientific attitude and emergency procedures regarding personal safety.	**3/3**	**U, Ap**	**C**	**L**	
CO-5	Discuss about applications of different types of natural and synthetic polymers.	**1/1**	**U**	**F**	**L**	

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

Mapping of COs with PSOs and POs

	PSO 1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	2	1	-	-	-	-
CO 2	1	3	-	-	1	1	-	-	-	2
CO 3	1	2	3	-	2	2	-	-	-	-
CO 4	-	1	2	-	2	-	1	-	-	1
CO 5	3	1	-	-	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	✓			✓

Discipline	Polymer Chemistry				
Course Code	**UK2DSCPOC102**				
Course Title	Introductory Organic 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	A comprehensive understanding of organic chemistry principles, including electron movement, molecular structure, resonance, and biochemistry, is necessary to comprehend organic reaction mechanisms, isomerism, aromaticity, and natural polymer synthesis and properties.				
Course Summary	The course covers the fundamental principles of organic reaction mechanisms, exploring how molecules undergo chemical transformations through various reaction pathways. Additionally, it delves into the structural diversity of organic compounds, including isomerism, the unique stability and reactivity of aromatic compounds, and the synthesis and properties of natural polymers derived from biological sources.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**Organic Reaction Mechanism I**	**9**
	1	Definition of reaction mechanism. Drawing of electron movements with arrows: curved arrow notation, Half headed and double headed arrows. Nature of bond fissions: Homolytic and Heterolytic fission with suitable examples. Types of reagents: Electrophiles and Nucleophiles. Nucleophilicity and basicity, Electrophilicity and acidity.	4
	2	Electron displacement effects: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation, steric effect and their applications.	5
II		**Organic Reaction Mechanism II**	**9**
	3	Reaction intermediates: Carbocations, carbanions, free radicals (definition, hybridization, structure, formation (primary, secondary, tertiary, allyl, benzyl) and stability	4
	4	Introduction to types of organic reactions: Addition reactions: mechanism of addition of bromine and hydrogen halides to double bonds (Markownikoff’s rule and peroxide effect), Elimination	5

		reaction: 1,1 and 1,2 eliminations, (Hoffmann and Saytzeff rule), Substitution reaction: nucleophilic substitutions: mechanism of SN1 and SN2 reactions, Electrophilic substitution - reactions with special reference to simple aromatic compounds	
III		**Isomerism in Organic Compounds**	**9**
	5	General, Types of Isomerism, Structural isomerism, stereo isomerism, optical isomerism, Geometrical isomerism, resolution, racemization	4
	6	Asymmetric synthesis, Walden inversion, stereospecific and stereoselective synthesis, tautomerism, difference between tautomerism and resonance.	5
IV		**Aromatic compounds**	**9**
	7	Introduction, sources of aromatic compounds, structural representation of benzene and other benzenoid compounds	4
	8	Electrophilic substitution reactions of Benzene. Synthesis of aromatic compounds using nitration, sulphonation halogenation and Friedel-Craft alkylations	5
V		**Natural Polymers-II**	**9**
	9	General methods of polymerization, Chain polymerization- Free radical, cationic and anionic. Polyaddition and polycondensation. Molecular mass, biopolymers	5
	10	Structure of natural polymers-silk, wool, DNA, Starch, cellulose and proteins. Applications of natural polymers.	4

Introductory Organic Chemistry II   Practical – 30 Hours

Module	Unit	Content	Hrs
I		**General Instructions**	**10**
	1	Readiness to follow Laboratory rules and regulations and cooperating with Lab instructors and staff for avoiding accidents	3
	2	Laboratory safety measures, develop safety skills by wearing lab coats, gloves and safety eye glasses wherever necessary (Necessity of FIRST AID and of keeping first Aid box in Lab)	3

	3	Procedures adopted in chemical splashes to skin, eyes, burns and electric shock, Instruction for emergency use of Fire extinguishers in Lab	2
	4	Labels and warning symbols for Safe handling of Toxic and corrosive chemicals. Familiarization of MSDS of common laboratory chemicals	2
II	**Preparations of Organic compounds**		**20**
	5	Halogenation: Bromination of acetanilide	3
	6	Nitration of Acetanilide or nitrobenzene	3
	7	Oxidation of benzaldehyde/Toluene/Benzyl chloride	3
	8	Acetylation of salicylic acid or aniline	3
	9	Benzoylation of phenol or aniline	3
	10	Hydrolysis of ethyl acetate and benzamide	3
	11	Boiling point of simple organic compounds	2

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4. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
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7. S. C. Sharma and M. K. Jain, Modern Organic Chemistry, Golden Jubilee Ed.; Vishal Publishing Company, New Delhi, 2020.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Apply the electron displacement effects to compare acidity,basicity and stability od organic compounds/ intermediates.	**Ap**	**1,2**
CO-2	Students will gain the ability to understand the reaction intermediates and the types of organic reactions.	**U**	**1,2**
CO-3	Learners will be able to identify and classify different types of isomerism in organic compounds, including structural, stereoisomers, and conformational isomers, enhancing their ability to interpret molecular structures and predict properties.	**U**	**1,2**
CO-4	Through studying aromatic compounds, students will develop an understanding of the unique stability and reactivity associated with benzene rings, as well as the principles of resonance and aromaticity, facilitating their comprehension of aromatic substitution reactions and related phenomena.	**U**	**1,2**
CO-5	The course will provide insight into the synthesis, structure, and properties of natural polymers such as proteins, carbohydrates, and nucleic acids, allowing students to appreciate the diverse roles these macromolecules play in biological systems.	**U,Ap**	**1,5**
CO-6	Obey Lab safety instructions, develop qualities of punctuality, regularity and scientific attitude, out look and scientific temper (GOOD LAB PRACTICES) and students will acquire practical skills in organic synthesis, preparation of organic compounds, learners will deepen their understanding of reaction mechanisms and the factors that influence chemical reactivity, such as functional group compatibility, stereochemistry, and regioselectivity, empowering them to predict and rationalize the outcomes of synthetic reactions.	**Ap**	**4,6,7**

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

Name of the Course: Introductory 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)
CO-1	Understanding the electron displacement effects and its applications.	**1/1,2**		**C**		
CO-2	Students will gain the ability to understand the reaction intermediates and the types of organic reactions.	**1/1,2**		**C**		
CO-3	Learners will be able to identify and classify different types of isomerism in organic compounds and predict properties.	**1/1,2**		**C**		
CO-4	Appreciation of Aromaticity	**1/1,2**		**C**		
CO-5	Insight into Natural Polymer Chemistry.	**1/5**		**C**		
CO-6	Obey Lab safety instructions, develop qualities of punctuality, regularity and scientific attitude, out look and scientific temper (GOOD LAB PRACTICES) and skills in preaparation of organic compounds and understanding Reaction Mechanisms	**2,6,8/ 4,6,7**		**P**		

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

Mapping of COs with PSOs and POs

	PSO 1	PSO 2	PSO 4	PSO 5	PSO 6	PSO 7	PO1	PO2	PO 3	PO 4	PO 6	PO8
CO 1	2	3	-	-	-	-	3	-	-	-	-	-
CO 2	2	3	-	-	-	-	3	-	-	-	-	-
CO 3	3	3	1	-	-	-	3	-	-	-	-	-
CO 4	3	3	2	3	-	-	3	-	-	-	-	-
CO 5	-	-	-	3	-	-	3	-	-	-	-	-
CO 6	-	-	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		✓		✓
CO 6			✓	

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2DSCPOC103**				
Course Title	Basics of Physical 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	Basic understanding of chemical reactions and stoichiometry. Familiarity with mathematical concepts including algebra and calculus. Knowledge of thermodynamics fundamentals such as energy, entropy, and the laws of thermodynamics. Understanding of equilibrium concepts in chemistry, including chemical equilibrium and solution equilibrium. Basic knowledge of atomic structure and bonding.				
Course Summary	To provide students with a comprehensive understanding of chemical kinetics, dilute solutions, thermodynamics, colloids, and ionic equilibrium, enabling them to analyse various chemical processes and phenomena at an advanced level.				

Detailed Syllabus

Module	**Unit**	**Content**	**Hrs**
I		**Chemical Kinetics**	**9**
	1	Order and molecularity of Reaction, Derivation of Integrated Rate Equation of Zero, First, Second and nth Order Reaction and Examples.	2
	2	Determination of Order of Reactions: Graphical and Analytical Methods using Integrated Rate Equations, Fractional Life Method, Differential Rate Equation Method, Isolation Method.	2
	3	Qualitative Idea of Chain Reactions.	1
	4	Influence of Temperature on Rate of Reaction: Arrhenius Equation, Determination of Arrhenius Parameter, Energy of Activation and its Significance.	2
	5	Reaction dynamics: Collision theory of bimolecular reaction	2
II		**Dilute solutions**	**9**
	6	Introduction to solutions: definition, types of solution	1
	7	Concentration of solution: molality, molarity, normality and mole fraction	2
	8	Colligative Properties: Lowering of Vapour Pressure; Elevation of Boiling Point and Depression in Freezing Point; Molal Elevation Constant, Molal Depression Constant, Osmosis and Osmotic Pressure, van’t Hoff Equation.	3
	9	Determination of Molecular Mass of Solute by Beckmann	3

		Method and Cooling Curve Method. Abnormal Molecular Mass-Van't Hoff Factor. Determination of Degree of Dissociation and Association.	
III		**Thermodynamics II**	**9**
	10	Second Law of Thermodynamics. Different Statements, Need for second law of Thermodynamics.	1
	11	The Carnot Cycle and its Efficiency. Carnot's Theorem and its Proof.	1
	12	Concept of Entropy- Definition and Physical Significance. Entropy Changes in Reversible and Irreversible Processes and in Phase Changes.	2
	13	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. Significance of Gibbs-Helmholtz Equation.	3
	14	Partial Molar Quantities: Chemical Potential. Gibb's - Duhem Equation. Concept of Fugacity. Determination of Fugacity of a Gas by Graphical Method.	2
IV		**Colloids**	**9**
	15	Colloidal state: Classification of colloids- Kinetic, optical and electrical properties of colloids.	2
	16	Purification of colloids – ultra filtration and electro dialysis, Ultra microscope, Electrical double layer and zeta potential. Coagulation of colloids, Hardy-Schulz rule, Gold number. sedimentation and streaming potential	3
	17	Gels: Elastic and non-elastic gels, Imbibition and syneresis, Micelles and critical micelle concentration	2
	18	Application of colloids – Cottrell precipitator, purification of water and delta formation.	2
V		**Ionic equilibrium**	**9**
	19	Ionic Product of Water, Effects of Solvents on Ionic Strength, Levelling Effect.	1
	20	Ionic Equilibrium: Ionic Product of Water, Effects of Solvents on Ionic Strength, Levelling Effect.	2
	21	Ionization of Weak Acids and Bases. pKa and pKb values. Solubility Product and Common Ion Effect and their Applications.	2
	22	pH and its Determination by Indicator Methods. Buffers and Calculation of their pH - Henderson's Equation.	2
	23	Hydrolysis of Salts of all types. Degree of Hydrolysis and Hydrolysis Constant. Relation between Hydrolysis Constant and Ionic Product of Water.	2

Basics of Physical Chemistry- II Practical – 30 Hours

Module	Unit	Content	Hrs
I		**General Instructions**	**10**
	1	Readiness to follow Laboratory rules and regulations and cooperating with Lab instructors and staff for avoiding accidents	3
	2	Laboratory safety measures, develop safety skills by wearing lab coats, gloves and safety eye glasses wherever necessary (Necessity of FIRST AID and of keeping first Aid box in Lab)	3
	3	Procedures adopted in chemical splashes to skin, eyes, burns and electric shock, Instruction for emergency use of Fire extinguishers in Lab	2
	4	Labels and warning symbols for Safe handling of Toxic and corrosive chemicals. Familiarization of MSDS of common laboratory chemicals	2
II		**Physical chemistry experiments**	**20**
	6	Determination of order of the reaction using graphical method	2
	7	Investigation of the effect of temperature on reaction rate and determination of the activation energy using the Arrhenius equation.	2
	8	Determination of heat capacity of calorimeter	2
	9	Measurement of entropy changes in reversible and irreversible processes	2
	10	Determination of ionic product of water	2
	11	Determination of solubility product of sparingly soluble salt	2
	12	Determination of the molar mass of a solute by measuring the freezing point depression of a solvent	2
	13	Determination of freezing point depression constant of a solvent	2
	14	Investigation of Tyndall effect using colloidal and true solution	2
	15	Study of coagulation phenomena and determination of critical coagulation concentration	2

References

1. K. J. Laidler, P. G. Mahajan, Chemical Kinetics and Reaction Mechanisms, Prentice-Hall of India Pvt.Ltd, 3rd Edition, 2009
2. P.W. Atkins, Julio de Paula, Physical Chemistry, Oxford University Press, 10th Edition, 2014

3. J. M. Smith, H. C. Van Ness, M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill Education, 7th Edition,2005
4. S.C. Arora, Colloid and Surface Chemistry, S. Chand & Company Ltd, 11th Edition, 2014
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of reaction kinetics, determination of reaction order, derivation of rate equations for complex reactions, application of Arrhenius equation	R,U,E, Ap	1,2
CO-2	Identification of different type of solution and classification, calculation of concentration using various units, application of colligative properties	R, U, Ap	1,2
CO-3	Understand the need for thermodynamics, understand and analyse Carnot’s theorem, calculation of entropy changes of different process, application of thermodynamic equations	R, U, E,Ap	1,2
CO-4	Understanding colloids and its classification, analysing the application of colloids in water purification	R, U, E	1,2
CO-5	Understand and analyse ionic equilibrium and ionic product of water, understand solubility product, determination of pH, understand and analyse hydrolysis of water	R, U, E	1,2

CO-6	understanding of various principles and techniques in physical chemistry, including kinetics, thermodynamics, and colloidal chemistry. They also emphasize the practical application of these concepts in experimental settings.	R, U, Ap,An	1,2,3

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

Name of the Course: Basic Physical 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	Understanding of reaction kinetics, determination of reaction order, derivation of rate equations for complex reactions, application of Arrhenius equation	**1,2/1,2**	**R,U,E, Ap**	**F, C**	**L**	
2	Identification of different type of solution and classification, calculation of concentration using various units, application of colligative properties	**1,2/1,2**	**R, U, Ap**	**F, C**	**L**	
3	Understand the need for thermodynamics, understand and analyse Carnot's theorem, calculation of entropy changes of different process, application of thermodynamic equations	**1,2/1,2**	**R, U, E, Ap**	**F, C**	**L**	
4	Understanding colloids and its classification, analysing the application of colloids in water purification	**1,2/1,2**	**R, U, E**	**F, C**	**L**	
5	Understand and analyse ionic equilibrium and ionic product of water, understand solubility product, determination of pH, understand and analyse hydrolysis of water	**1,2/1,2**	**R, U, E**	**F, C**	**L**	

6	understanding of various principles and techniques in physical chemistry, including kinetics, thermodynamics, and colloidal chemistry. They also emphasize the practical application of these concepts in experimental settings.	**1,2.5/1,2,3**	**R, U, Ap,An**	**F,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
CO 1	2	2	-	-	-	2	2	-	-	-
CO 2	2	2	-	-	-	2	2	-	-	-
CO 3	2	2	-	-	-	2	2	-	-	-
CO 4	2	2	-	-	-	2	2	-	-	-
CO 5	2	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	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2DSCPOC104**				
Course Title	Introductory 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	Idea of general concepts on acids and bases. An understanding of importance of metal ions in living systems A basic idea of types of bonds in chemistry and coordinate bond				
Course Summary	This course provides a basic understanding of different concepts of acids and bases and describes the applications of non-aqueous media. It is also intended to provide basic concepts in coordination chemistry, organometallic compounds, and bioinorganic chemistry.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**Acids and Bases**	**9**
	1	General concept of acids and bases, Theories of acids and bases-Arrhenius, Bronsted-Lowery (conjugated acid base concept), Lux Flood, Solvent system (auto-ionization) and Lewis concepts.	3
	2	Solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents – discussion with examples. Super acids and super bases: examples.	2
	3	Pearson's Hard-Soft Acid-Base Concept (HSAB) concept. Bonding in hard–hard and soft–soft combinations. Examples	2
	4	Applications of HSAB Concept	1
II		**Non-Aqueous Solvents**	**9**
	5	Non–aqueous solvents– classification of solvents, general characteristics of common solvents, protic and aprotic nonaqueous solvents- examples	2
	6	Reaction in non-aqueous solvents: self-ionization and levelling effect, acid-base strength in non-aqueous solvents.	2

	7	Solutions of metals in liquid Ammonia, self-ionization of liquid ammonia, alkali metals in liquid ammonia.	3
	8	Liquid SO_2 and liquid HF as non-aqueous media. Applications of non–aqueous solvents.	2
III	**Bioinorganic Chemistry**		**9**
	9	Bioinorganic chemistry- Role of metal ions in biological systems	2
	10	Biochemistry of iron: Haemoglobin and Myoglobin-basic functions	2
	11	Photosynthesis (Brief discussion of light and dark reactions), Sodium - Potassium pump	2
	12	Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity	3
IV	**Basics of coordination chemistry**		**9**
	13	Coordinate bond and coordination compounds- introduction, ligands and their classifications, IUPAC nomenclature of coordination complexes	2
	14	Werner Theory, Valance bond theory – Hybridization in metal complexes - Inner orbital and Outer orbital complexes – introduction to the spectral and magnetic properties of complexes	3
	15	Isomerism in coordination complexes – structural isomerism – brief discussion on stereoisomerism (geometrical and optical isomerism)	3
	16	General Applications of Coordination compounds, Applications in analytical chemistry	1
V	**Organometallic Chemistry**		**9**
	17	Definition and nomenclature of organometallic compounds.	2
	18	Classification as Sigma, Pi and mixed (containing both Sigma and pi) complexes, 18 electron rule	2
	19	Metal carbonyls- mononuclear and polynuclear (examples with Fe, Co and Ni)	2
	20	Organometallic compounds of Mg, Li, Zn and Cu (Preparation and important applications)	3

Introductory Inorganic Chemistry Practical – 30 Hours

Module	Unit	Content	Hrs
I		**Preparation of Inorganic Complexes**	**30**
	1	Potash alum	3
	2	Hexamine cobalt Chloride	3
	3	Tetraamine copper Sulphate	3
	4	Mohr's salt	3
	5	Microcosmic salt	3
	6	Sodium cobalt nitrite	3
	7	Sodium nitroprusside	3
	8	Manganese phthalocyanine	3
	9	Potassium trioxalatochromate	3
	10	Potassium trioxalatoferrate	3

References

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2. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers New Delhi, 2010.
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6. R. Gopalan, V. Ramalingam, Concise coordination chemistry, 1^{st} Edn., Vikas Publishing house, 2001.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Conceptual understanding various definitions of acids and bases	**U**	**1, 2**
CO-2	Understand reactions in non-aqueous solvents.	**U**	**1**
CO-3	Nomenclature of coordination compounds, bonding and isomerism	**R, U**	**1**
CO-4	Discuss various bioinorganic processes like photosynthesis, working of sodium potassium pump, etc	**U, An**	**1**
CO-5	Name and classify organometallic compounds	**U**	**1**

CO-6	Identify the role of organometallic compounds in organic Synthesis	**U**	**1**
CO-7	Develop skill in preparing and purifying inorganic complex compounds	**Ap**	**4**

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

Name of the Course: Introductory Inorganic Chemistry

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

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Conceptual understanding various definitions of acids and bases.	**1/ 1, 2, 6**	**U**	**C**	**L**	
CO-2	Understand reactions in non-aqueous solvents.	**1 / 2, 6**	**U**	**F**	**L**	
CO-3	Nomenclature of coordination compounds, bonding and isomerism	**1 / 1, 2, 6**	**R, U**	**F**	**L**	
CO-4	Discuss various bioinorganic processes like photosynthesis, working of sodium potassium pump, etc.	**1 / 1, 2, 6**	**U, An**	**F**	**L**	
CO-5	Name and classify organometallic compounds	**1 / 2, 6**	**U**	**F**	**L**	
CO-6	Identify the role of organometallic compounds in organic synthesis	**1 / 1, 2, 6**	**U**	**F**	**L**	
CO-7	Develop skill in preparing and purifying inorganic complex compounds	**4 / 1, 2, 6**	**Ap**	**M**		**P**

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

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO6	PO7	PO8
CO 1	2	1	-	-	2	1	-	1	-	-
CO 2	2	-	-	-	-	1	-	1	-	-
CO 3	2	-	-	-	2	1	-	1	-	-
CO 4	2	-	-	-	2	1	-	1	-	-
CO 5	2		-	-	-	2	-	1	-	-
CO 6	2	-	-	-	-	2	1	-	1	-
CO 7	-	-	-	2	-	2	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	✓	✓		✓
CO 6			✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2DSCPOC105**				
Course Title	Synthetic Polymers				
Type of Course	DSC				
Semester	2				
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 idea about polymers 2 Basic knowledge in organic chemistry				
Course Summary	This course explore the diverse properties and applications of thermoplastics and thermosetting plastics. The course also provide an understanding of reinforcing polymers. The couse gives an idea of polymer testing techniques and explores the synthesis of monomers from petrochemicals.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**Thermoplastic polymers**	**9**
	1	Definition of thermoplastics .Classification of thermoplastics.	2
	2	Molecular structure-polymer chains, inter molecular forces and crystallinity.	2
	3	properties of thermoplastics-mechanical,thermal and electricalproperties.	3
	4	Applications of thermoplastics.	2
II		**Thermosetting polymers**	**9**
	5	Definition and classification ofthermosetting polymers.	2
	6	Molecular structure and cross linking	2
	7	Properties-mechanical,thermal electrical properties,chemical resistance and environmental stability.	3
	2	Application of thermosetting polymers	2
III		**Reinforcement of polymers**	**9**
	9	Definition and importance of polymer reinforcement.	1
	10	Reinforcement materials-fibres,fillers,nanoparticles	2
	11	Properties and selection criteria for reinforced materials.	2
	12	Propertiesof reinforced polymers-mechanical,electrical and thermal properties.	2
	13	Benefits and challenges of reinforced polymer composite.	2
IV		**Polymer testing standard**	**9**

	14	Importance of testing standards in polymer industry.Overview of standard organisations like ASTM international, ISO etc.Role of testing standard in product development and quality control.	3
	15	Mechanical testing of polymers-Tensile testing,compression testing,flexural testing impact testing	2
	16	Thermal l testing of polymers-TGA, DSC	2
	17	Chemical testing of polymers-chemical composition analysis-elemental testing, spedtroscopic technique.	2
V		**Synthesis of monomer from petrochemicals**	**9**
	18	Introduction to monomer synthesis-importance of petrochemicals in polymer production.	2
	19	Ethylene sand synthesis and polymerisation	2
	20	Propylene synthesis and polymerisation.	2
		Green chemistry principles in monomer synthesis and polymerisation.	3

Synthetic Polymers Practical : 30 Hrs

Module	Unit	Content	Hrs
I		**Tensile testing of polymers**	**5**
	1	Measure the strength and elasticity of polymer samples-5 samples	
II		**Impact testing of polymers**	**5**
	2	Measure the toughness and impact resistance of polymers-5 samples	
III		**Hardness testing of Polymers**	**5**
	3	Measuring the hardness of polymer using hardness tester-5 samples	
IV	4	Presentation on the application of testing standards in a specific industry.	**5**
V	5	Case studies of real-world applications of thermoplastics and thermosetting plastics.	**10**

References

1. John A. Manson and Lynn H., Polymer testing-new methods and Standardization, Springer publishers, 1976.
2. John D. Askew, Monomer Synthesis: Petrochemica Routes to Polymer Science, Elsevier science, 2004.
2. Shah V., Handbook of Plastic Testing & Technology, Wiley-Inter science, 2007
3. Hylton D., Understanding Plastic Testing, Hanser publication, 2004.
4. Grellmann W., Seidler S., Polymer Testing, Hanser publication, 2013.
5. L.C. Hollaway and P.R. Head, Advanced Polymer Composites and Polymers in the Civil Infrastructure, Woodhead publishers, 2001.

<u>Course Outcomes</u>

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

		Level	
CO-1	Understand the molecular structure and properties of thermoplastics. And thermosetting polymers.	**U**	**1, 2**
CO-2	Understand the fundamentals of polymer reinforcement and different types of reinforcement materials.	**R, U**	**1, 2**
CO3	Familiarise with industry standard testing methods and procedures established by ISO,ASTM International and NIST.	**U, A**	**1, 2**
CO4	Understand the chemical pathways for monomer synthesis from petrochemical feedstock.	**U, A**	**1, 2**
CO5	Gain practical skills in conducting polymer test, analysing test data and interpreting test result.	**Ap, An**	**1, 2, 3**

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

Name of the Course: Synthetic Polymers

Credits: 3:0:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understand the molecular structure and properties of thermoplastics. And thermosetting polymers.	**1, 2/1, 2**	**U**	**C**	**L**	
2	Understand the fundamentals of polymer reinforcement and different types of reinforcement materials.	**1, 2/1, 2**	**R, U**	**C**	**L**	
3	Familiarise with industry standard testing methods and procedures established by ISO,ASTM International and NIST.	**1, 2/1, 2**	**U, A**	**C**	**L**	
4	Understand the chemical pathways	**1, 2/1, 2**	**U, A**	**C**	**L**	

	for monomer synthesis from petrochemical feedstock.					
5	Gain practical skills in conducting polymer test, analysing test data and interpreting test result.	**1, 2, 3/1, 2, 3**	**Ap, An**	**P**		**P**

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

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO3	PSO6	PO1	PO2	PO3	PO4	PO6
CO 1	2	2	-	-	2	2	-	-	-
CO 2	2	2	-	-	2	2	-	-	-
CO 3	2	2	-	-	2	2	-	-	-
CO 4	2	2	-	-	2	2	-	-	-
CO 5	2	2	-	-	2	2	-	-	-
CO 6	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		✓		✓
CO 6			✓	

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2DSCPOC106**				
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	Idea of general concepts in chemistry. A basic idea of types of bonds in chemistry and coordinate bond				
Course Summary	This course provides a basic understanding of different concepts of environmental chemistry and green chemistry and describes the synthesis and applications of Nano science. It also covers basic concepts in biomedical polymers and functional polymers.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**Environmental Chemistry II**	**9**
	1	Environment – Lithosphere- Soil, Components of soils, Hydrological cycle, water and river water composition. Fresh water, Surface water and ground water.	1
	2	Air pollution, Sources, pollutants, CO, NOx, SOx, Hydrocarbons, Particulates Ozone layer importance, Ozone depletion, Control measures.	2
	3	Acid rain, Control of acid rain, Greenhouse effect-global warming,-photochemical smog- Effect pollution on plants and human being.	1
	4	Water Pollution – Sources –Industrial effluents- Agriculture discharge - oil spills-heavy metal - pesticides-Bio magnifications, Bioaccumulations, Micro plastics.	1
	5	Soil Pollution - Sources by industrial and urban wastes, plastics, heavy metals, radioactive pollutants.	1
	6	Thermal pollution-Sources of thermal pollution, Harmful effect of thermal pollution, Prevention of thermal pollution. Reverses osmosis and Electro dialysis.	1
	7	Environment and public health- Climate and health-Hazardous products-Risks due to chemicals in food and environment. Plastic Waste -Management and Handling, Narmada Bachavo Andolan and Chipko movement.	2
II		**Green Chemistry II**	**9**
	8	Green synthesis – Microwave assisted reactions in water, Microwave assisted reaction in organic solvent-Esterification, oxidation and nitration. Ultrasound assisted reaction.	2

	9	An overview to green synthetic methods, including waste reduction processes in amide bond formation, alkene reduction (basic idea).	2
	10	Solvent use and alternatives to toxic solvents; Ionic liquids, water, supercritical carbon dioxide (scCO2) and applications to industrial settings.	2
	11	Renewable feed stocks and recycling (basic idea)	1
	12	Development of green method: synthesising polylactic acid from corn- Green chemistry in sustainable development. (Bio-diesel, bio-ethanol and biogas)	2
III		**Nano science II**	**9**
	13	Quantum effects, Preparation and Characterization: Top-Down and Bottom-Up approaches of nanomaterial (nanoparticles, nanoclusters and quantum dots)	2
	14	Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co precipitation; Metal nanocrystals by reduction.	2
	15	Sol-gel synthesis, Solvothermal synthesis, Self-assembled monolayers (basic idea).	2
	16	Carbon nanotubes fullerenes and graphene.	1
	17	Properties of nanoparticles: optical, magnetic, mechanical, thermal and catalytic properties, Nano devices- Spintronics, Nanomagnetism (basic idea).	2
IV		**Biomedical polymers**	**9**
	18	Biopolymers - biodegradable polymers, Polymers in medical field. Important features for Biomedical Application: responsiveness, biodegradation and biocompatibility.	2
	19	Hydrogel, fibres, bioceramics, bio-elastomers (basic idea).	1
	20	Permanent implants for function-orthopaedics, cardio vascular, respiratory tubes, digestive system.	2
	21	Dental applications, denture bases, crown and bridge resins, maxillofacial prosthetic materials, restorative material, sealants, adhesives, dental impression and duplicating materials, agar, algmater elastomers.	2
	22	Silicone implants, Polymer membranes, Contact Lenses, Gas Permeable Lenses, Soft Lenses.	1
	23	Introduction to drug delivery, Polymers in controlled drug delivery- uses of cellulose, chitosan and alginate.	1
V		**Functional polymers**	**9**
	24	Conducting polymers, synthesis and properties of polyaniline, polyacetylene, polyphenylene, polythiophene, poly pyrrole	5
	25	Charge transfer polymers, Ionically conducting polymers	2
	26	Shape memory polymers, Temperature responsive polymers	1
	27	Electro responsive polymers, Self-healing polymers, Dielectric elastomers (basic idea)	1

General Chemistry II Practical – 30 Hours

Module	Unit	Content	Hrs
I		**Green synthesis**	**30**
	1	Esterification - Microwave assisted	2
	2	Base Hydrolysis -Microwave assisted	2
	3	Acid hydrolysis - Microwave assisted	2
	4	Oxidation reaction- Microwave assisted	2
	5	Nitration of Phenols using $Cu(NO_3)_2$- Microwave assisted	4
	5	Green synthesis of a compostable plastic polylactic acid made from corn	4
	6	Synthesis of silver nano particles	4
	7	Preparation and characterization of nanoparticles (Cu, Ag) using plant extract.	4
	8	Biodiesel from frying oil and vegetable oils	4
	9	Preparation of nano particles of gold using tea leaves extract.	2

References

4. A. K. Ahluwalia, Environmental Chemistry, Ane Books, India, New Delhi.
5. B. K. Sharma, Soil and Noise pollution, Krishna Prakashan Media.
6. Rashmi Sanghi, M. M. Srivasthava, Green Chemistry Environment Friendly Alternatives, Alpha Science.
7. J. P. Tierney, P. Lidstrom, Microwave Assisted Organic Synthesis, Blackwell Publishing.
8. F. W. Billmayer, Text book of Polymer Science, 3rd edition, John Wiley & Sons, 1984.
9. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer Science, New Age International Publishers 2005.
10. H. N. Cheng, Richard A. Gross, Patrick B. Smith, Green Polymer Chemistry Biobased Materials and Bio catalysis, American Chemical Society.
11. Dhorali Gnanasekaran, Green Biopolymers and Their Nanocomposites, Springer Nature Singapore, 2019.
12. Raja Shunmugam, Functional Polymers, Design, Synthesis, and Applications, Apple Academic Press, 2017.
13. Vinod B. Damodaran, Divya Bhatnagar, N. Sanjeeva Murthy, Biomedical Polymers: Synthesis and Processing, Springer, 2016.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Study different types of pollution and main features.	**U**	**1**
CO-2	Discuss about green synthesis and use of non-toxic solvents in production process.	**U, Ap**	**1**
CO-3	Discuss various synthetic methods in Nano science.	**R, Ap**	**5**

CO-4	Discusses bio polymers and its application.	**U, Ap**	**5**
CO-5	Study about different functional polymers.	**U**	**1**

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)
CO-1	Study different types of pollution and main features	**1/1**	**U**	**C**	**L**	
CO-2	Discuss about green synthesis and use of non-toxic solvents in production process.	**1/1**	**U**	**C**	**L**	
CO-3	Discuss various synthetic methods in Nano science.	**1,2/5**	**R, Ap**	**C**	**L**	**P**
CO-4	Discuss about bio polymers and its application.	**1/5**	**U, Ap**	**C**	**L**	**P**
CO-5	Study about different functional polymers.	**1/1**	**U**	**C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO 4	PSO 5	PO 1	PO2	PO3	PO4	PO5
CO 1	2	-	-	-	-	2	-	-	-	-

CO 2	2	-	-	-	-	2	-	-	-	-
CO 3	-	-	-	-	2	2	1	-	-	-
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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2MDCPOC101**				
Course Title	Biopolymers and Biomaterials				
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	Introduction to biopolymers and biomaterials and their applications				
Course Summary	Introduce students to various classes of biopolymers and biomaterials To develop understanding regarding the characteristics of polymers to be used as biomaterials To develop the understanding regarding the various applications of biopolymers and biomaterials.				

Detailed Syllabus

Module	Unit	Content	Hrs
I		**Introduction to biopolymers**	**9**
	1	Introduction of biopolymers	1
	2	Its classification on the basis of type, origin monomeric units.	2
	3	Sources of Biopolymers, Need for Biopolymers.	1
	4	Introduction, functions and applications of Cellulose, Cotton, Wool, Silk,	3
	5	Paper, Rubber, Collagen, Lignin	2
II		**Natural and synthetic biopolymers**	**9**
	6	Structure and functions of bio-polymers: Proteins, Nucleic acid and polysaccharides	2
	7	Structure and applications of starch, shellac and cellulose.	2
	8	Biopolymers from renewable resources. Biocompatibility requirements.	1
	9	Synthetic biopolymers: Polylactic acid and its co-polymers,	2
	10	Aliphatic polyesters, Polyethylene oxides and its copolymers	2
III		**Basics of biomaterials**	**9**
	11	Introduction of biomaterials- Natural and Synthetic, Concept of biocompatibility, degradation	2
	12	Biological material, Biodegradable material, Bio-resorbable material, Bio-inert material, Bio-active material, Pyrogenicity, Minimum Requirements of Biomaterials	2
	13	Bulk properties and Surface properties of Biomaterials.	1
	14	Host Reactions to Biomaterials: Inflammation; Wound healing and the Foreign body response	2

	15	Use of biomaterials for manufacture of plastic films, blends and their applications.	2
IV		**Polymers as Biomaterials**	**9**
	16	Bioactive Polymers, Biodegradable polymers: synthesis and characterization, degradation and structure-function relationship	1
	17	Polymers used as biomaterials- Silicon rubber, Dacron, polymethyl methacrylate, polyurethane and cellulose- and their application	3
	18	Technically important form of polymers: Hydrogel- synthesis and characterization, properties	2
	19	mechanically robust gels, biodegradable hydrogels, bioceramics, bioelastomers and membranes	2
	20	Composite Biomaterials: Brief introduction	1
V		**Applications of Biopolymers and biomaterials**	**9**
	21	Difference between Biopolymers and Synthetic Polymers	1
	22	Major applications of biopolymers and biomaterials	2
	23	Biomedical Applications of polymers- Cardiovascular Applications, Dental implants.	2
	24	Adhesives and Sealants, Opthalmologic Applications, Orthopedic Applications, Drug Delivery System	2
	25	Bioelectrodes, Biomedical Sensors and Biosensors	2

References

1. R. M Johnson, L Y Mwaikambo and N Tucker, Biopolymers, Rapra Technology 2003.
2. Susheel Kalia, Luc Avérous, Biopolymers: Biomedical and Environmental Applications, Scrivener Publishing, 2011.
3. Ajay Kumar Mishra, Chaudhery Mustansar Hussain, Shivani Bhardwaj Mishra, Biopolymers: Structure, Performance and Applications, Nova Science Pub Inc, 2017.
4. D. Byrom, Biomaterials- novel materials from biological sources' Palgrave Macmillan publishing, 1st edition, 1991
5. Joon B. Park, Joseph D. Bronzino, Biomaterials: Principles and Applications, CRC Press, 1st edition, 2002.
6. Schoen, F. J., Ratner, B. D., Hoffman, A. S., Lemons, J. E., Biomaterials Science: An Introduction to Materials in Medicine. Netherlands: Elsevier Science, 2004.
7. Hench, L. L., Ethridge, E. C, Biomaterials: an interfacial approach, United Kingdom: Academic Press,1982.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	The course aims to give a good knowledge regarding the material groups biopolymers and its source,	**U**	**1**

	classification, need etc. Get an awareness about the functions and applications of common biopolymers.		
CO-2	Expand their knowledge about biopolymers, polymer structure and they will recognize that biological functions which are based on the way the building blocks (nucleotides, amino acids, carbohydrates, etc.) are assembled. Knowledge about synthetic biopolymers also.	**R, U**	**1**
CO-3	Understand the concept of biomaterials, different types and its properties. Understand the interaction between biomaterial and host material. Understand the use of biomaterials for manufacture of plastic films, blends and their applications.	**U, R**	**1**
CO-4	This course will provide an introduction to the field of polymeric biomaterials. The types of material such as Hydrogel, bio ceramics, bio elastomers and membrane. Aware about composite Biomaterials	**R, U**	**5**
CO-5	To get an idea about the major applications of biopolymers and biomaterials. The vast applications of biomaterials will encourage students to explore them in detail and to design and engineer synthetic and natural materials for biomedical applications.	**U, R**	**5**

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

Name of the Course: Biopolymers and Biomaterials

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

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	The course aims to give a good knowledge regarding the material groups biopolymers and its source, classification, need etc. Get an awareness about the functions and applications of	**1/1**	**U**	**F, C**	**L**	

	common biopolymers.					
CO-2	Expand their knowledge about biopolymers, polymer structure and they will recognize that biological functions which are based on the way the building blocks (nucleotides, amino acids, carbohydrates, etc.) are assembled. Knowledge about synthetic biopolymers also.	**1/1**	**U**	**P**	**L**	
CO-3	Understand the concept of biomaterials, different types and its properties. Understand the interaction between biomaterial and host material. Understand the use of biomaterials for manufacture of plastic films, blends and their applications.	**1/1**	**R,U**	**F**	**L**	
CO-4	This course will provide an introduction to the field of polymeric biomaterials. The types of material such as Hydrogel, bio ceramics, bio elastomers and membrane. Aware about composite Biomaterials	**5/2**	**R,U**	**F**	**L**	
CO-5	To get an idea about the major applications of biopolymers and biomaterials. The vast applications of biomaterials will encourage students to explore them in detail and to design and engineer synthetic and natural materials for biomedical applications.	**5/2**	**U**	**F**	**L**	

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

Mapping of Cos with PSOs and POs

	PSO1	PSO5	PO1	PO2	PO3	PO4

CO 1	**3**	**-**	**3**	**-**	**-**	**-**
CO 2	**2**	**-**	**3**	**-**	**-**	**-**
CO 3	**3**	**-**	**2**	**-**	**-**	**-**
CO 4	**-**	**2**	**-**	**3**	**-**	**-**
CO 5	**-**	**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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK2MDCPOC102**				
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	Preliminary idea of chemicals				
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	Hrs
I		**Chemicals in daily life**	**9**
	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.	4
	3	Harmful effects of cosmetics. Herbal Cosmetics- Definition, Natural Ingredients used- Aloe Vera, Turmeric, Henna, Amla, Neem, Clove	3
II		**Food Additives**	**9**
	4	Food additives – Definition, Food Colours - Permitted and Non-permitted food colours.	2
	5	Artificial Sweeteners, Flavour Enhancers, Stabilizers and Thickening Agents, Fat emulsifiers and Flour treatment agents.	3
	6	Preservatives - Natural and Artificial Food Preservatives, Antioxidants, Nutritional Supplements.	3
	7	FSSAI, Food Safety and Standards Act	1
III		**Chemistry of Biomolecules**	**9**
	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.	3
	10	Vitamins – Classification, functions and deficiency diseases	2
	11	Enzymes, Hormones and Nucleic acids (Basic concept only)	2
IV		**Dyes and Pigments**	**9**
	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
V	**Chemistry In Medicines**		**9**
	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, Anti-hypertensive 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

References

1. B. K. Sharma, Industrial Chemistry-I,Krishna Prakashan,3rd edition,2023
2. B. Srilakshmi, Food Science,New Age International Private Limited, 6th edition, 2015
3. Shakuntala Manay "Foods: Facts & Principles"New Age International Private Limited; 2nd edition, 2001
4. Bhutani S.P, Chemistry of Biomolecule, Ane Books Pvt. Ltd, 2009
5. Sujata V. Bhat, B. A. Nagasampagi, S. Meenakshi, Natural Products,Springer-Verlag Berlin and Heidelberg GmbH & Co , 2004
6. David R. Waring and Geoffrey Hallas, The Chemistry and application of Dyes, Springer,1990
7. David E. Newton, Chemistry of Drugs, Facts On File Inc,2007.
8. Ashuthosh Kour,"Medicinal Chemistry", New Age International Publishers; 7th edition, 2018
9. Dr. Ramesh Kumari, Introduction to Cosmetic Chemistry, Prestige Books, 2021

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**	**6**
CO-2	Identify additives added to foods for various purposes	**R**	**6**
CO-3	Acquire knowledge of biomolecules	**U, R**	**1**

CO-4	To get a basic knowledge of dyes and pigments	**R**	**1**
CO-5	Acquire knowledge of commonly used drugs	**U, R**	**6**

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)
CO-1	Understand the components of commonly used cosmetics and their effects	**2/6**	**U**	**F**	**L**	
CO-2	Identify additives added to foods for various purposes	**2/6**	**R**	**F**	**L**	
CO-3	Acquire knowledge of biomolecules	**1/1**	**R,U**	**F**	**L**	
CO-4	To get a basic knowledge of dyes and pigments	**2/1**	**R**	**F**	**L**	
CO-5	Acquire knowledge of commonly used drugs	**2/6**	**R,U**	**F**	**L**	

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

Mapping of COs with PSOs and POs

	PSO1	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	-	3	-	-	-	-
CO 2	-	3	-	3	-	-	-	-

CO 3	2	-	2	-	-	-	-	-
CO 4	2	-	-	3	-	-	-	-
CO 5	-	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	✓	✓		✓

Discipline	POLYMER CCHEMISTRY				
Course Code	**UK3DSCPOC201**				
Course Title	Physical Chemistry of Polymers				
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. A basic understanding of polymers 2. A basic understanding Thermodynamics.				
Course Summary	The course focuses on the principles of polymer chemistry. Students will explore topics like polymer structure, polymerisation mechanisms and molecular interactions,				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Molecular Forces**	**9**
	1	Interactions in polymers. Polar, Non polar interactions. entanglement of polymers. Primary structure-polarity of monomers Secondary structure Conformation and configuration Tertiary structure- Crystalline and amorphous polymers segmental mobility and total mobility of polymers. Influence of inter molecular forces on polymer properties-melting point, solubility, mechanical strength.	5
	2	Solid, liquid, glassy and rubbery states. Amorphous and crystalline behaviours	2
	3	Factors affecting crystallinity-chain regularity,packing efficiency	2
II		**Kinetics and thermodynamics of polymerisation reactions**	**9**
	4	Mechanism and kinetics of chain growth polymerization, kinetic chain length, thermal and electrical polymerization, auto acceleration	2
	5	Mechanism and kinetics of anionic and cationic polymerizations, counter ions. Termination modes	2
	6	Mechanism of condensation and step growth polymerisation.Thermodynamic properties in polymerisation reaction-Gibb’s free energy change,enthalpy change and entropy .Spontaneity of polymerisation reactions.	3
	7	Equilibrium constantant and its significance in polymerisation reaction.	2
III		**Structure and properties of polymers**	**9**
	8	Chemical structure of polymers-linear,branched and cross linked	2
	9	Crystallinity and crystalline structure of polymers. Tm of polymers.Impact of crystalline structure on properties of polymers-mechanical,thermal and barrier properties.	2

	10	Amorphous regions and Tg of polymers and their impact on properties -mechanical,thermal and barrier properties.	2
	11	Molecular weight of polymers-effect of molecular weight on properties of polymers-mechanical,thermal and barrier properties.	3
IV		**Characterisation of polymers**	**9**
	12	Importance of polymer characterisation in material science and engineering.Overview of analytical techniques.	2
	13	Applications of FTIR, NMR (proton and C-13) and X-ray diffraction in characterization.	2
	14	Thermal analysis, Differential Thermal analysis and Thermogravimetric analysis and differential scanning calorimetry in characterization of Polymers	3
	15	Mechanical testing for property analysis-tensile,flexural and impact testingof polymers.	2
V		**Properties of polymer solutions**	**9**
	16	Definition and classification of polymer solutions.	1
	17	Application of polymer solutions in various industries.	2
	18	Viscosity of polymer solutions. Factors affecting viscosity. Viscosity average molecular weight.	3
	19	Rheological properties of polymer solutons.-shear thinning behaviour and viscoelasticity.	3

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2. V. R. Gowariker, N. V. Viswanathan&J. Sreedhar, Polymer Science, New Age International Publishers, 2005
3. P. Bahadur, N. V. Sastry, Principles of Polymer Science, Narrora Publishing House, 2nd Edition, New Delhi, 2006
4. P. Ghosh, Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, 3rd edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2011.
5. G, Odian, Principles of polymerization, 3rd edition, John Wiley & Sons, 2004.
6. V. K. Ahluwalia & A. Misra, Polymer Science-A Text Book, Ane Books, India, New Delhi, 2016.
7. R. Fried, Polymer Science & Technology, Prentice Hall of India Pvt. Ltd, New Delhi, 2014.

Physical chemistry of Polymers. Practical - 30 Hrs

Module	Content	Hrs
I	Case study on structure-property relationship of Poly Ethylene -HDPE and LDPE	**10**
II	Determination of viscosity of any three polymer solutions using viscometer.	**10**

III	Rheological characterisation of any three polymer solutions at various concentrations.	**10**

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Explain the preliminary techniques for the characterization of polymers	**R, U**	**PSO-1**
CO-2	Apply sophisticated techniques to characterize polymers.	**U, Ap**	**PSO-1,5**
CO-3	Explain kinetics and mechanism of polymerisation reactions	**U**	**PSO-1,2**
CO-4	Explaining different molecular forces and structure of polymers.	**U**	**PSO-1**
CO-5	Develop skill in viscosity determination and rheological characterisation of polymer solutions and i presenting case study report.	**U,Ap**	**PSO-4,7**

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

Name of the Course: Physical Chemistry of Polymers; Credits: 3:0:1 (Lecture:Tutorial: Practical)

CO No.	**Course Outcomes**	**PO/ PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Explain the preliminary techniques for the characterization of polymers	1/1	R, U	F, C	L	
CO-2	Apply sophisticated techniques to characterize polymers.	1/1,5	U, Ap	P	L	
CO-3	Explain kinetics and mechanism of polymerisation reactions	1/1,2	U	C	L	
CO-4	Explaining different molecular forces and structure of polymers	1/4,7	U	C	L	
CO-5	Develop skill in viscosity determination and rheological characterisation of polymer solutions and i presenting case	2,4,7 /1	U, Ap	P		P

	study report					

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

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 7	PO1	PO2	PO3	PO4	PO5	PO7
CO 1	2	-	-	-	-	-	2					
CO 2	2	-	-	-	2-	-	2					
CO 3	2	-	3	-	-	-	2					
CO 4	2-	-	-	-	-	-	2			2		2
CO 5	2	-	-	-	-	2	2					
CO 6	-	-	-	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			✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSCPOC202**				
Course Title	Organic 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. Students should have a solid understanding of foundational concepts in organic chemistry 2. Students should have a knowledge of fundamental organic reactions such as substitution, addition, elimination, and oxidation-reduction reactions				
Course Summary	Provide students with an in-depth understanding of the principles governing organic reactions, with a focus on hydrocarbons and their derivatives				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Reaction Mechanisms and Hydrocarbon**	**9**
	1	Electron displacement effect - inductive, electrometric, resonance, hyper conjugation and steric effects.	2
	2	Homolytic and heterolytic fission of bonds.	1
	3	Reactive intermediates – carbocations, carbanions, free radicals, carbenes, nitrenes and benzyne.	3
	4	Arenes: Aromaticity. Huckel's rule; non-benzenoid aromatic compounds. Polynuclear hydrocarbons –preparation of Naphthalene, anthracene and phenanthrene, its resonance structures – aromatic electrophilic substitution. Directive influence of substituent such as -OH, - NH_2, -NO_2, Alkyl groups and halogens.	3
II		**Introduction to Stereochemistry**	**9**
	5	Elements of symmetry, chirality, stereogenic centre, enantiomers, chiral and achiral molecules with two stereogenic centres, diastereoisomers, meso compounds, resolution, inversion and racemization.	3
	6	Absolute and relative configuration, D-L, R-S systems of nomenclature, Priority and sequence rules.	3
	7	Asymmetric synthesis. Geometrical isomerism: E-Z systems of nomenclature. Geometric isomerism of maleic and fumaric acid and butadiene.	3
III		**Reaction Mechanism**	**9**

	8	Types of organic reaction – substitutions (in aliphatic and aromatic) SN_1, SN_2 and SNi reactions and mechanisms.	3
	9	Addition reactions (electrophilic and nucleophilic) Mechanism of addition of hydrogen, hydrogen halide to alkenes and alkynes - free radical addition, Markownikoff's rule and Kharasch effect.	3
	10	Elimination reactions - E_1 & E_2. Stereochemistry of the above reactions. Saytzeff's and Hofmann's rules. Competition between elimination and substitution.	3
IV	**Alcohols, Phenols and Halogen Compounds**		**9**
	11	Alcohols, phenols and ethers: Methods of preparation (hydroboration & hydration of alkene) Special emphasis to oxymercuration, demercuration, hydroboration, oxidation and anti-hydroboration, crown ethers.	2
	12	Preparation, properties and industrial applications of ethylene glycol and glycerol.	1
	13	Pinacol- pinacolone rearrangement. Mechanisms – Reimer-Tiemann reaction, Kolbe reaction. Fries and Claisen rearrangements and their mechanisms. Phthalein reaction.	2
	14	Preparation and properties of catechol, resorcinol, quinol, and naphthols. Ziesel's method of estimation of alkoxy group.	2
	15	Halogen compounds: methods of preparation (from alcohol and alkene) and properties, synthetic uses of vinylchloride, chloroform, carbon tetrachloride, chloroprene, Freon-12, DDT, and BHC.	2
V	**Aldehydes and Ketones**		**9**
	16	Aldehydes and Ketones: - General methods of preparation: Grignard reaction; oxidation reaction. General chemical reactions.	3
	17	Reduction using $LiAlH_4$, Sodium borohydride and Aluminium isopropoxide – comparative study.	2
	18	Mechanism of Wolff-Kishner reduction, Clemmenson reduction, Aldol condensation and Benzoin condensation.	3
	19	Preparation and uses of crotonaldehyde, mesityl oxides, cinnamaldehyde, salicylaldehyde and vanillin.	1

Organic Chemistry I Practicals – 30 HOURS

Module	Content	Hrs (30)
I	**Detection of Elements**	2
	Lassaigne's test for Nitrogen, Sulphur and Halogen	
II	**Solubility Tests**	2
	Classification of compounds into water soluble/insoluble	
	Classification of compounds into ether soluble/insoluble	
	Solubility in Na_2CO_3	

	Solubility in NaOH	
	Solubility in HCl	
III	**Tests for Aliphatic and Aromatic compounds**	2
	(i) Ignition test (ii)Nitration test	
IV	**Tests for Saturated and Unsaturated Compounds**	2
	(ii) Oxidation (ii) Bromination	
V	**Tests to distinguish between following compounds**	8
	Monocarboxylic acid and dicarboxylic acid	
	Primary, secondary and tertiary amines	
	Monoamide and diamide	
	Aldehyde and ketone	
	Reducing and non-reducing sugars	
	Monohydric phenols and dihydric phenols	
VI	**Reactions of common functional groups using known organic compounds**.	6
VII	**Systematic qualitative analysis with a view to characterization of the following functional groups**	8
	Halo compounds: chlorobenzene, benzyl chloride,	
	Phenols: phenol, *o* ,*m* ,*p* -cresols, naphthols, resorcinol	
	Aldehydes and ketones: benzaldehyde, acetophenone, benzophenone	
	Carboxylic acids: benzoic, phthalic, cinnamic and salicylic acids	
	Esters: ethyl benzoate, methyl salicylate	
	Amides: benzamide, urea	
	Anilines: aniline, *o*,*m*, *p* - toluidines, dimethylaniline	
	Nitro compounds: nitrobenzene, *o*- & *p*- nitro toluene	
	Poly nuclear hydrocarbons: naphthalene, anthracene	
	Reducing and non-reducing sugars: glucose and sucrose	

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1. K. S. Tewari, S.N. Mehrotra and N. K. Vishnoi, “A Text Book of Organic Chemistry”, Vikas Publishing House (Pvt) Ltd., New Delhi, 1998.

2. I. L. Finar, Organic Chemistry Vol – 1 & 2, 5th Edition, Pearson Education, New Delhi, 2002.
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4. R. T. Morrison and R. T. Boyd, Organic Chemistry, Prentice-Hall, Sixth Edition, 2001.
5. F. A. Carey, Organic Chemistry. McGraw Hill, Fourth Edition, 2000.
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10. S. M. Mukherji and S. P. Singh, Reaction Mechanisms of Organic Chemistry, Macmillan, 2014.
11. M. K. Jain, A Text Book of Organic Chemistry, 2020.
12. A. Bahl and B.S. Bahl, Advanced Organic Chemistry, S. Chand & Company, New Delhi, 2012.
13. P. S. Kalsi, Stereochemistry and Mechanism through Solved Problems, New Age International, 2006.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of electron displacement effects, knowledge of bond fission, familiarity with reactive intermediates, understanding of arenes and aromaticity	**U, R**	**1,2**
CO-2	Understanding of symmetry and chirality, comprehension of enantiomers and chiral molecules, analysis of molecules with multiple stereogenic centres, knowledge of configuration nomenclature, proficiency in resolution, inversion and recemization	**R, U, Ap**	**1,2**
CO-3	Understanding of organic reaction types, proficiency in substitution reaction, understand the mechanism of addition and elimination reaction	**R, U, Ap**	**1,2**
CO-4	understanding of the preparation, properties, and synthetic applications of alcohols, phenols, ethers, and halogen compounds, the knowledge and skills necessary to apply these concepts in organic synthesis	**R, U, Ap**	**1,2**
CO-5	understanding of the properties, reactions, and synthetic applications of aldehydes and ketones, knowledge and skills necessary to apply in organic synthesis and	**R, U, Ap**	**1,2**

	industrial processes		
CO-6	to perform qualitative analysis of organic compounds, identify functional groups, and interpret experimental data effectively, develop practical laboratory skills and critical thinking abilities essential for further studies and research in organic chemistry and related fields	**R, U, An, E**	**1, 2, 3, 6**

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

Name of the Course: Organic chemistry - I Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	Course Outcomes	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
1	Understanding of electron displacement effects, knowledge of bond fission, familiarity with reactive intermediates, understanding of arenes and aromaticity	**1, 2/1, 2**	**U, R**	**C**	**L**	
2	Understanding of symmetry and chirality, comprehension of enantiomers and chiral molecules, analysis of molecules with multiple stereogenic centres, knowledge of configuration nomenclature, proficiency in resolution, inversion and recemization	**1, 2/1, 2**	**R, U, Ap**	**C**	**L**	
3	Understanding of organic reaction types, proficiency in substitution reaction, understand the mechanism of addition and elimination reaction	**1, 2/1, 2**	**R, U, Ap**	**C**	**L**	
4	understanding of the preparation, properties, and synthetic applications of alcohols, phenols, ethers, and halogen compounds, the knowledge and skills necessary to apply these concepts in organic synthesis	**1, 2/1, 2**	**R, U, Ap**	**C**	**L**	
5	understanding of the properties, reactions, and synthetic applications of	**1, 2/1, 2**	**R, U, Ap**	**C**	**L**	

	aldehydes and ketones, knowledge and skills necessary to apply in organic synthesis and industrial processes					
6	to perform qualitative analysis of organic compounds, identify functional groups, and interpret experimental data effectively, develop practical laboratory skills and critical thinking abilities essential for further studies and research in organic chemistry and related fields	**3, 4, 5, 6/1, 2, 3, 6**	**R, U, An, 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	PSO4	PSO5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	-	2	2	-	-	-	-
CO 2	2	2	-	-	-	-	2	2	-	-	-	-
CO 3	2	2	-	-	-	-	2	2	-	-	-	-
CO 4	2	2	-	-	-	-	2	2	-	-	-	-
CO 5	2	2	-	-	-	-	2	2	-	-	-	-
CO 6	2	2	-	-	2	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	Assignm ent	Project Evaluation	End Semester Examinations
CO 1	√	√		√
CO 2	√	√		√
CO 3	√	√		√
CO 4	√	√		√
CO 5	√	√		√
CO 6	√		√	√

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSCPOC203**				
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 h	-	2 h	5
Pre-requisites	Basic knowledge of Physical Chemistry				
Course Summary	This course has been designed to provide a reasonable understanding of chemical kinetics, binary liquid systems, non-spectroscopic methods, catalysis, and photochemistry				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Gaseous State**	**9**
	1	Maxwell's distribution of molecular velocities (No derivation) average, most probable and rms velocities, processes	2
	2	collision number and collision frequency, mean free path	2
	3	deviation of gases from ideal behaviour – Boyle temperature, derivation of vander Waals constants and critical constants – Law of corresponding states – reduced equation of state,	3
	4	Joule Thomson effect, liquefaction of gases – Linde's and claude's processes	2
II		**Crystalline State**	**9**
	5	Isotropy and anisotropy – symmetry elements in crystals – the seven crystal systems.	2
	6	Miller indices, Bravais lattices, primitive, bcc and hcc of cubic crystals – Representation of lattice planes of simple cubic crystal	2
	7	Density from cubic lattice dimension – calculation of Avogadro number - Bragg equation, diffraction of Xrays by crystals – single crystal and powder method.	3
	8	Detailed study of structures of NaCI and KCl crystals.	2
III		**Non-spectroscopic Methods**	**9**
	9	Dipole moment, Debye equation and Clausius-Mosotti equation, Dipole moment and molecular structure.	3
	10	Diamagnetism and paramagnetism, Magnetic susceptibility and unpaired electrons, measurement of magnetic susceptibility	3

	11	Molar refraction and molecular structure, atomic refraction, Optical exaltation, Parachor and atomic equivalent of parachor.	3
IV	**Group Theory**		**9**
	13	Group theory- elements of symmetry- proper and improper axis of symmetry- plane of symmetry-centre of symmetry- identity elements,	3
	14	combination of symmetry elements point group- C_{2v}, C_{3v} and D_{3h}	3
	15	Group multiplication table of C_{2v}	1
	16	Determination of point group of simple molecules like water, NH_3, BF_3	2
V	**Binary Liquid System**		**9**
	17	Completely miscible liquid pairs, vapour pressure - composition curve, boiling point-composition curve- ideal and non-ideal solutions	2
	18	fractional distillations, azeotropes	1
	19	Partially miscible liquids - CST, phenol- water, nicotine-water system- Effect of impurities on miscibility and CST,	3
	20	Immiscible liquid pairs, steam distillation- Distribution law and its limitations, applications of solvent extractions.	3

Physical Chemistry Practical I – 30 Hours

Module	Content	Hrs
	Preparation of Inorganic Complexes	**30**
I	**Phenol-water (Binary liquid systems)**	
	Critical solution temperature of phenol –water system	3
	Influence of KCl (impurity) on the miscibility temperature of phenol-water system. Determination of concentration of given KCl solution	3
II	**Surface tension**	
	Determination of Surface tension of any three liquids	4
	Determination of parachor value of $-CH_2-$	4
	Determination of unknown concentration of acetic acid	4
III	**Refractive index experiments**	
	Determination of refractive indices of any three liquids	3
	Refractive indices of KCl solutions of different concentrations and determination of concentration of unknown KCl solution	3
IV	**Partition experiments**	
	Partition coefficient of iodine between CCl4 and H2O or Partition coefficient of ammonia between CHCl3 and H2O	6

References

1. P. W. Atkins, Physical Chemistry, 12th Edn**,** Oxford University Press, 2022
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10. G. W. Castellan, Physical Chemistry, Narosa Publishing House, 2004
11. B. Viswanathan, P. S. Raghavan A Practical Physical Chemistry, Viva Books, 2012

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the physical concepts in gaseous state, crystalline state, binary liquid systems, non-spectroscopic methods and group theory	**U**	**PSO 1**
CO-2	Understand the effect of temperature on molecular velocities of gases	**U**	**PSO 2**
CO-3	Draw unit cells and structure of crystals	**U**	**PSO 2**
CO-4	Evaluate physical and chemical quantities using non-spectroscopic techniques.	**U, E**	**PSO 2**
CO-5	Differentiate diamagnetism and paramagnetism, measurement of magnetic susceptibility	**U**	**PSO 1**
CO-6	Correlate dipole moment with geometry of molecules	**R, A**	**PSO 2**
CO-7	Compare theory with experimental findings	**A**	**PSO 4**
CO-8	Practice Punctuality and regularity in doing experiments and submitting Lab records	**A**	**PSO 4**

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

Name of the Course: Physical Chemistry-I Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	Course Outcomes	PSO/PO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the physical concepts in	**1/ 1, 2,**	**U**	**F**	**L**	

	gaseous state, crystalline state, binary liquid systems, non-spectroscopic methods and group theory	**6**				
CO-2	Understand the effect of temperature on molecular velocities of gases	**2/ 1, 2, 6**	**U**	**C**	**L**	
CO-3	Draw unit cells and structure of crystals	**1/ 1, 2, 3, 6**	**U**	**P**	**L**	
CO-4	Evaluate physical and chemical quantities using non-spectroscopic techniques.	**2/ 1, 2, 3, 6**	**U, E**	**P**	**L**	
CO-5	Differentiate diamagnetism and paramagnetism, measurement of magnetic susceptibility	**1/ 1, 2, 3, 6**	**U**	**P**	**L**	
CO-6	Correlate dipole moment with geometry of molecules	**2/ 1, 2, 3, 6**	**R, A**	**P**	**L**	
CO-7	Compare theory with experimental findings	**4/ 1, 2, 3, 6**	**A**	**M**		**P**
CO-8	Practice Punctuality and regularity in doing experiments and submitting Lab records	**4/ 1, 2, 3, 6**	**A**	**M**		**P**

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

Mapping of COs with PSOs and POs:

	PSO 1	**PSO2**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	2	-	2	1	-	-	-	1	-	-
CO 2	-	2	2	1	-	-	-	1	-	-
CO 3	-	2	1	2	2	-	-	1	-	-
CO 4	-	2	1	2	2	-	-	1	-	-
CO 5	2		1	2	2	-	-	1	-	-
CO 6	-	2	1	2	2	-	-	1	-	-
CO 7	-	-	1	2	2	-	-	1	-	-
CO 8	-	-	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	✓			✓
CO 6	✓	✓		✓
CO 7	✓			✓
CO 8	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSCPOC204**				
Course Title	Environmental Chemistry				
Type of Course	DSC				
Semester	3				
Academic Level	200 - 299				
Soil Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 h	5
Pre-requisites	1. Idea of general aspects of water, air and soil. 2. Basic idea of Environmental laws, environmental disasters.				
Course Summary	Familiarize with the water analysis techniques, to analyse acidity and alkalinity, Gain knowledge on BOD and COD, Effects of air pollution viz. Global warming etc. Soil Pollution , Basic soil analysing techniques				

Detailed syllabus:

Module	Unit	content	Hrs
I		**Water Pollution**	**9**
	1	Basic aspects of water- Types of water - general properties of water (physical and chemical). Major sources of water Pollution 1.Eutrophication; 2.Acid Mine Drains 3. Pesticides and Fertilizers; 4. Dying and Tanning	3
	2	Basics of Sampling, sampling procedure, measurement of water quality and their analysis, water quality standards, BOD and COD . Hard water & soft water	2
	3	Water Pollution Treatment 1. Introduction; 2. Technological Approach; 3. Chemical Degradation of wastes and Chemicals; 4. Coagulation and flocculation; 5.Photocatalytic degradation of pollutants; 6.Supercritical water oxidation	2
	4	Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones), thermal pollution and its effects.	2
II		**Air Pollution**	**9**
	5	What is Air Pollution – Primary & Secondary air pollutants - Smog & Soot – hazardous air pollutants – Greenhouse gases – pollen & mold	2
	6	Effects of air pollution – Diseases – Global warming – Acid Rain – Ozone layer depletion – Effect on animals	2
	7	Environmental and Health impacts of Air Pollution.	3
	8	Air Pollution Control Measures – Air Quality Index	2
III		**Soil Pollution**	**9**

	9	Introduction – soil pollution by industrial wastes. soil pollution by urban wastes, Radioactive pollutants and Agricultural waste-chemical and metallic pollutants-Biological agents – Mining	2
	10	Detrimental effects of soil pollutants – Effects of industrial pollutants- Effects of sewage and domestic wastes - Effects of heavy metals- Effects of radioactive pollutants- Effects of modern agro- technology – Diseases caused by soil pollution	2
	11	Solid waste management – sources and classification -public Health Aspects – methods of collection- Disposal methods – potential methods of disposal.	2
	12	Air pollution in India – Strategies to control air pollution in India – Clean Air Research Initiative (CARI)- National Air Quality Index – Real Time Air Quality Index (AQI) – National Clean Air Programme (NCAP) – World Air Quality Report 2023.	3
IV		**Major Environmental Laws**	**9**
	13	Environment Related Provisions in Indian Constitution - History of Environmental Laws in India	2
	14	Wild Life Protection Act, 1972; The Water (Prevention and Control of Pollution) Act , 1974 ; The Air (Prevention and Control of Pollution) Act ,1981; And The Environment (Protection) Act, 1986; The ozone-depleting substances (regulation and control) rules , 2000 .	3
	15	The Energy Conservation Act, 2001; Biological Diversity Act 2002; Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA) ; The National Green Tribunal Act, 2010	2
	16	Compensatory Afforestation Fund Act, 2016; E Waste (Management Rules 2016) ,Coastal Regulation Zone Notification 2018 , International Treaties and Agreements on Environment to which India is a signatory .	2
V		**Environmental Disasters – Case Study**	**9**
	17	Natural and man-made Disasters - How can natural disasters impact the environment? Water pollution in river Ganges, Yamuna ; Soil Pollution by micro plastics in Bhopal ; Air pollution in Delhi, Kolkata .	2
	18	Odisha Super Cyclone, 1999; Bhuj Earthquake, 2001; Indian Ocean Tsunami, 2004; Uttrakhand Floods, 2013; Cyclone Phailin, 2013	2
	19	Environmental disasters in the World - 1986: CHERNOBYL; 1976: Seveso Dioxin Cloud ; 2010: The deepwater horizon oil spill; 2020: Baia mare cyanide spill; 2002 : Oil fires in Kuwait	2
	20	Bhopal Gas Tragedy , Oil Spills in India, Kodaikanal Mercury poisoning, Effect of Pokhran Nuclear Testing , Sasthamcotta Folidol Tragedy COVID-19 pandemic in Kerala	3

Environmental Chemistry Practical – 30 Hours

Detailed Syllabus:

Module	Content	Hrs
I	**Module I: General Instructions**	**10**
	Readiness to follow Laboratory rules and regulations and cooperating with Lab instructors and staff for avoiding accidents	3
	Laboratory safety measures, develop safety skills by wearing lab coats, gloves and safety eye glasses wherever necessary (Necessity of **FIRST AID** and of keeping first Aid box in Lab)	3
	Procedures adopted in chemical splashes to skin, eyes, burns and electric shock, Instruction for emergency use of **Fire extinguishers in Lab**	2
	Labels and warning symbols for Safe handling of Toxic and corrosive chemicals. Familiarization of MSDS of common laboratory chemicals	2
II	**Environmental Analysis, BOD & COD**	**20**
	Water Analysis - Physical Tests - temperature, Specific conductance or electrical conductance (EC) or conductivity, total suspended solids (TSS)) and turbidity.	5
	Analytical Methods - pH, BOD, chemical oxygen demand (COD), dissolved oxygen (DO)	5
	Water Analysis - Total hardness, nutrients - nitrogen and phosphorus compounds, (e.g. nitrate and orthophosphates) .	5
	Soil Analyis - To study soil samples from two different sites and analyse their properties such as texture, moisture content, water-retaining capacity and pH.	5

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1. S. S. Dara, D. D. Misra, A Text book of Environmental Chemistry& Pollution control, 2004.
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3. Banerji, K. Sameer, Environmental Chemistry, 2009.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Major sources of water Pollution , measurement of water	**U**	**8**

	quality and their analysis, Water Pollution Treatment , Sources of marine pollution and their management.		
CO-2	Primary & Seconday air pollutants, Effects of air pollution, Environmental & Health Impacts , Control measures.	**U**	**8**
CO-3	Soil pollutants , detrimental effects of soil pollutants, solid waste management, Strategies to control soil pollution.	**U**	**8**
CO-4	Environmental Laws , Prevention & Pollution Acts , International Treaties and Agreements on Environment etc	**U, Ap**	**8**
CO-5	Environmental disasters as case studies	**U, E**	**8**

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

Name of the Course: Environmental Chemistry Credits: 3:0:1 (Lecture:Tutorial: Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Major sources of water Pollution , water quality analysis, Water Pollution Treatment .	**2/8**	**U**	**C**	**L**	
CO-2	Air pollutants, Environmental & Health Impacts , Control measures.	**2/8**	**U**	**C**	**L**	
CO-3	Soil pollutants , its detrimental effects, Strategies to control soil pollution	**2/8**	**U**	**C**	**L**	
CO-4	Environmental Laws , Prevention & Pollution Acts	**2/8**	**U, Ap**	**P**	**L**	
CO-5	Environmental disasters as case studies	**1/8**	**U , E**	**F**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO8	PO1	PO2
CO 1	2	-	2
CO 2	2	-	2
CO 3	2	-	2

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	✓			✓

<table>
<tr><td>Discipline</td><td colspan="5">POLYMER CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK3DSCPOC205</td></tr>
<tr><td>Course Title</td><td colspan="5">Chemistry in Day-to-Day Life</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">Basic idea about chemicals in day-to-day life</td></tr>
<tr><td>Course Summary</td><td colspan="5">To have a thorough awareness of the ways that chemistry influences several facets of our daily lives. Includes the fundamental aspects of cleansing agents, its environmental and health impacts. An overview about different drugs and their mode of action. It also includes fundamentals of food additives, fuels and explosive chemistry.</td></tr>
</table>

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Cleansing Agents**	**9**
	1	Chemistry of cleansing agents: natural and synthetic cleaning agents, chemistry of cleaning action, Types of cleansing agents- Detergents, Soaps, Degreasers and disinfectants- advantages and uses in various cleaning applications.	2
	2	Introduction of detergents & Surfactants, Terminology use in detergents industry, Raw materials and washing action of detergent, Role of pH in detergent manufacturing.	2
	3	Chemistry of soap: Raw material for soap industry, chemical reactions of soaps: Hard and Soft soaps, flavor and fragrance used in soap manufacture, Liquid dish wash and Liquid hand wash.	2
	4	Environmental and health impacts: Bio degradability, Toxicity and eco friendliness, Safety consideration.	2
	5	Regulatory compliance and standards for common cleansing agents	1
II		**Drugs**	**09**
	6	Introduction to drugs: Overview of classification of drugs with examples- central nervous system (CNS) depressants, CNS stimulants, hallucinogens, dissociative anesthetics, narcotic analgesics, inhalants, and cannabis.	3

	7	General introduction to Analgesics, antipyretics, antiseptics, disinfectants, Antihypertensive, Tranquilisers and Antibiotics with examples.	2
	8	Principles and mechanism of drug action, Structural effects on drug action	2
	9	Sulpha drugs- Brief introduction, important sulpha drugs, its chemistry and uses	1
	10	Anti-malarials, Anti-histamines, Narcotics and Chemotherapy	1
III		**Explosives**	**9**
	11	Fundamentals of explosive chemistry: overview of explosives- History, classification and applications.	1
	12	Basic principles of chemical reaction, synthesis, decomposition and detonation of explosives such as energetic materials , reaction kinetics and thermodynamics	2
	13	Design principles of explosives, Synthesis methods and formulation techniques, Performance optimization and stability consideration	2
	14	Explosives safety and handling: Safety regulations and standards, Storage, transportation and handling procedures.	2
	15	Common explosives , its applications and environmental effects: Dynamite, C-4, TNT, RDX, PETN, ANFO	2
IV		**Fuels**	**9**
	16	Introduction to fuels: Basic knowledge about solid, liquid and gaseous fuels, their origin and classification.	1
	17	Production, properties and various measurements of solid, liquid fuels and their measurement techniques.	2
	18	Common gaseous fuels: Natural gases, Methane from coal mines, Producer gas, water gas, biogas, refinery gas, LPG, hydrogen, acetylene, other fuel gases.	2
	19	Combustion: Principle of Combustion, 3 T's of Combustion, Brief explanation about Combustion of Oil, Coal, Gas, Combustion Controls	2
	20	Bio-Fuels: Types of Bio-fuels, production processes and technologies, Bio-fuel applications. Brief discussion about Alternative Fuels and Energy Systems	2
V		**Food Additives**	**9**
	21	Overview of food additives: Brief introduction, Evolution of food additives in food industry, Purpose and classification.	1
	22	Introduction of food additives: Different types of food additives, its purpose, risk and benefits.	2
	23	Methods of food additive application: Direct vs indirect food additives- Differentiation and Application,	2

		Incorporation methods- mixing, emulsification, encapsulation and coating	
	24	E-numbers for different food additives, Major qualitative tests for the identification of additives in food, Brief discussion about Preservatives, Role of acidulants, stabilizers, leaving agents in food items.	2
	25	Assessment of food additive safety: FSSAI, Food safety and Standards act, Acute and chronic toxicity, Geno toxicity and Developmental toxicity studies.	2

Chemistry in day -today life: Practical: 30 Hrs

Module	Contents	Hrs (30)
I	BASIC LABORATORY TECHNIQUES: • Knowledge of Laboratory chemicals- hazard symbols, warning symbols, safety precautions and storage of chemicals • Cleaning of glassware – • Basic first aid techniques for cuts & bruises, burn injury etc. • Common Instruments used in laboratories • Distillation and deionisation apparatus and use • Laboratory management system	5
II	Methods of Detection Adulterants in any of the following Foods; Milk, Coffee, Oil (Ghee), Grain(pulses) , Sugar, Spices (Chili powder, turmeric, coriander) Processed food, Fruits and vegetables	10
III	1.Natural Material required for soap (Neem/Aloevera /Rose petals / Lavender/Reetha (any two) 2. Drying and Purification 3. Extraction of natural oil 4. Synthesis of soap 5. Identification of Natural Organic Detergents 6. Preparation of detergents for dishes/clothes 7. Testing of pH of the detergent.	15

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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 cleansing agents in daily life and their safety concerns.	**U**	**1**
CO-2	Acquire knowledge about commonly used drugs and its mode of action.	**U**	**1**
CO-3	The course would also enable the students to aware of the fundamental of explosive chemistry and commonly used explosives, its safety and environmental effects.	**U, An**	**2**
CO-4	The course introduces *basic* knowledge about solid, liquid and gaseous *fuels*, their origin, classification and combustion mechanism.	**U, An,**	**1**
CO-5	Get an awareness about the additives added to foods for various purposes and its safety assessment.	**U, Ap**	**3**
CO-6	Proficiency in analytical techniques	**Ap**	**3,4,6,7**

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

Name of the Course: Chemistry in day- today life; Credits: 3:0:1 (Lecture:Tutorial: Practical)

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

1	Understand the basic concepts of cleansing agents in daily life and their safety concerns.	**1/1**	**U**	**F, C**	**L**	
2	Acquire knowledge about commonly used drugs and its mode of action.	**1/1**	**U**	**C**	**L**	
3	The course would also enable the students to aware of the fundamental of explosive chemistry and commonly used explosives, its safety and environmental effects.	**1/2**	**U, An**	**C**	**L**	
4	The course introduces *basic* knowledge about solid, liquid and gaseous *fuels*, their origin, classification and combustion mechanism.	**1/1**	**U, An,**	**C**	**L**	
5	Get an awareness about the additives added to foods for various purposes and its safety assessment.	**2/3**	**U, Ap**	**C,P**	**L**	
6	Proficiency in analytical techniques	**2,3,6,8/3,4,6,7**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO4**	**PSO5**	**PSO 6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	-	-	-	-	-	1					
CO 2	1	3	-	-	-	-	1					
CO 3	1	-	-	-	-	-		2				
CO 4	1	-	-	-	-	-	1					
CO 5	-	2	-	-	-	-			3			
CO 6	-	-	3	3	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	✓	✓		✓
CO 6	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSCPOC206**				
Course Title	Polymer Composites and Analysis				
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. Basic idea about polymer chemistry. 2. Elementary idea about analytical chemistry. 3. Basic knowledge in organic chemistry.				
Course Summary	This course offers an in depth understanding of polymer composites and their preparation and characterization. It also offers a primary knowledge on various processing and analysis protocols of different polymer composites.				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Polymer Composites - Introduction**	**9**
	1	Introduction – classification, theory of composites, Various reinforcements and matrix materials used in Polymer composites - Glass fibres reinforcements – carbon and Kevlar fibres – inorganic fibres- natural fibres – polyester resins – epoxy resins – phenolic resins, Carbon-Carbon composites.	3
	2	Introduction to polymer nanocomposites, Layered silicates – carbon nanotubes – Inorganic nanofillers, Ceramic/polymer nanocomposites, Metal/polymer nanocomposites – Biomimetic nanocomposites.	2
	3	Polymer-layered silicate nanocomposites: Types of nanoclays, Preparation of polymer-layered silicate nanocomposites.	1
	4	Carbon nanotube (CNT) Reinforced polymer nanocomposites: dispersion properties of CNT nanocomposites, Mechanical properties and Conductivity of nanotube-polymer nanocomposites.	3
II		**Polymer Blends and Alloys - An overview**	**9**
	5	Definition for blends, alloys and copolymers, Reason for blending, classification of polymer blends, and methods of blending, selection criteria of blending; Design of polymer blends.	3

	6	Introduction, miscible blends and immiscible blends, difference between blends and alloys, Properties of miscible and immiscible blends.	3
	7	Factors affecting miscibility: Thermodynamics, compatibility, solubility parameter, interaction parameter. Popular Compatibilization techniques.	3
III		**Polymer Testing**	**9**
	8	Specification and Standards, National and International Standards, Basic understanding of stress–strain behavior of plastic materials. Testing of mechanical properties – tensile strength, compressive strength, impact strength, abrasion resistance, fatigue resistance, hardness.	3
	9	Major environmental factors affecting plastics and rubbers– accelerated weathering test, outdoor weathering of plastics, microbiological resistance. Water absorption test, Chemical resistance, Environmental stress cracking resistance, Gas permeability, Moisture absorption.	3
	10	Preliminary and chemical Identification of thermosets and rubbers – Raw materials characterization of thermosets - moisture content, particle size, apparent density, flow test, gel time, acid value, hydroxyl value, isocyanate index, epoxy equivalent. Analysis of latex - viscosity, Total solid content, Dry rubber content, alkalinity, KOH number.	3
IV		**Polymer Processing**	**9**
	11	Compounding, Principles of mixing – types of mixing, dispersive & distributive mixing, batch and continuous mixing, mastication and mechanism of mixing, banbury mixing master batching.	3
	12	Methods of polymer processing techniques-Compression moulding –Importance of flash positive, semi-positive type compression mould, Injection moulding-different types-RIM, RRIM.	2
	13	Vulcanization techniques-Batch vulcanisation methods, Autoclave, Hot air oven, Continuous vulcanization.	1
	14	Extrusion process- Pipe extrusion, Sheet forming process, Blow film extrusion, Extrusion blow moulding, Wire coating.	2
	15	Principles of Calendaring- Production of supported and unsupported sheeting, Textile coating-Skim coating.	1
V		**Chromatographic Techniques in Polymers**	**9**
	16	Thin layer chromatography, High performance liquid chromatography, Gel permeation chromatography.	6
	17	Gas chromatography and Size exclusion chromatography-theory and instrumentation.	3

Polymer Composites and Analysis lab – 30 Hours

Module	Content	Hour
	Polymer composite and analysis lab	**30**
1	Analyze particle size of nanomaterials (nanoparticles).	2
2	Chemical modification of nanoclay and its characterization	2
3	To prepare polymer blends by melt and solution blending.	2
4	To prepare polymer nanocomposites by solution casting.	2
5	Measurement of dielectric strength of polymer films/sheets.	2
6	Determination of environment stress cracking resistance of PE/PP films.	2
7	Measurement of abrasion resistance of polymer sheets.	2
8	Determine the refractive indices of polymer blends by using abbe's refractometer.	2
9	Determination of water absorption, aging resistance.	2
10	Determination of optical properties, melting point, thermal conductivity.	2
11	Industrial Visit	10

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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss about various concepts in polymer composites.	**U**	**PSO1**
CO-2	Discuss about different types of polymer blends and alloys and its thermodynamic features.	**U**	**PSO5**
CO-3	Understand different standards and procedures in polymer testing.	**U, Ap**	**PSO5**
CO-4	Discuss about different polymer processing techniques.	**U, Ap**	**PSO5**
CO-5	Discuss about different chromatographic techniques in polymer science.	**U**	**PSO1**

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

Name of the Course: Polymer Composites and Analysis; Credits: 3:0:1 (Lecture: Tutorial:Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Discuss various concepts in polymer composites.	**PO1 /PSO1**	**U**	**C**	**L**	
CO-2	Discuss about different types of polymer blends and alloys and its thermodynamic features.	**PO2 /PSO5**	**U**	**F**	**L**	
CO-3	Understand different standards and procedures in polymer testing.	**PO1 /PSO5**	**U, Ap**	**F**	**L**	**P**
CO-4	Discuss about different polymer processing techniques.	**PO1 /PSO5**	**U, Ap**	**F**	**L**	**P**
CO-5	Discuss about different	**PO1**	**U**	**F**	**L**	

	chromatographic techniques in polymer science	**/PSO1**				

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
CO 1	2	-	-	-	1	-	-	-	-	2
CO 2	1	2	-		1		2	-	-	-
CO 3	-	1	1		3	1	-		-	-
CO 4	2	1	-	-	-	2	-	-	-	-
CO 5	-	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
- Project Evaluation
- Final Exam
- Industrial visit and report

Mapping of COs to Assessment Rubrics:

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

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSEPOC201**				
Course Title	Commercial Polymers				
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	-	Nil	4 hours
Pre-requisites	Basic understanding of chemistry, particularly inorganic and organic chemistry and knowledge of atomic structure, chemical bonding, and the structure and properties of different elements and compounds.				
Course Summary	Commercial polymers serve the society in multidimensional ways and are critical components of the broad industrial sector, regulating the economics of a country also. They are used immensely in many products ranging from common use to even space vehicles. Their easy processability, versatility, high performance, durability, tunable properties and economic nature make them attractive candidates for a modern society.				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Introduction to commercial polymers**	**12**
	1	Polymers-History, Classification based Origin, Structure and properties	2
	2	Commercial Polymers: Polymerisation chemistry, Structure and properties: Processability (MFI, Solution and Melt Viscosity), Mechanical properties-Stress-Strain behaviours, Modulus and hardness, tensile strength, tear strength, viscoelastic behaviour, Thermal properties: Glass transition temperature, Crystalline melting point, Crystallisation temperature, Electrical properties: conductivity, dielectric strength, loss factor, Optical properties-refractive index, opaque, translucent and transparent nature, relation to composition and crystallinity.	4
	3	Processing Methods: Processing, curing and molding aspects of elastomers for product manufacturing, Thermoplastic- Extrusion, Injection Molding, Blow Molding, Thermosetting plastic-Compression molding and Transfer molding – (mention only), Fibers: Fiber characteristics and parameters, Spinning methods and electrospinning of nanofibers	3
	4	Individual Commercial polymers, Elastomers, Homopolymers, Amorphous elastomers, Amorphous and crystalline Thermoplastics, Copolymers (Elastomers and plastics),	3

		Thermosetting polymer-Inherent Properties, Additives for property modifications and matching for commercial requirement, Fibres: Natural and synthetic fibers, Fibers and crystallinity, Specialty fibers (PAN, Carbon, PET, PBT, Cellulose based fibers), Commercial Applications	
II	**Commercial Elastomers**		**12**
	5	Elastomers (Natural Rubber (cis and trans), nitrile rubber, polychloroprene, butyl rubber, polybutadiene, Copolymer Elastomers, Styrene-butadiene Rubber, EPDM, Silicone rubbers, Structure and inherent properties.	3
	6	Chemically modified elastomers, modification of specific properties for commercial applications, Chemistry of modification, characterisation and quality control	3
	7	Additives, mixing, blending and curing of elastomers, elastomer blends and composites, nanocomposites, characterisation and quality control of products, crosslinking agents, Commercial Applications product designs and prototyping	3
	8	Simple identification of elastomers, reclaiming processes for recycling, B2B concepts	3
III	**Thermoplastics**		**12**
	9	Polyolefins -LDPE, HDPE, PP, Vinyl polymers -PVC, PVA, PS and Copolymers (SBS, ABS), Structure-Property Correlations, Blending for property modification, Common additives and composites, Best Molding Techniques, Commercial Applications	3
	10	Acrylics-PAN, PAA, PMA, PMMA, Polyamides -Nylon 6, Nylon6,6, Polyesters-PET, PBT- Blending, for property modification, Common additives and composites, Best Molding Techniques, Commercial Applications	3
	11	Cellulose and its derivatives- Cellulose acetates, Cellulose nitrate- Blends and composites, Lignins, Chitin, Chitosan, properties Commercial Applications	3
	12	Copolymer-ABS, SBS, structure-property correlations, Molding Techniques, Commercial Applications, Aspects of thermoplastics, identification for recycling.	3
IV	**Thermosets**		**12**
	13	Thermosetting resins, Formaldehyde resins- Phenol Formaldehyde Resin, comparison of curing process and product quality and stability	3
	14	Phenol Formaldehyde Resin (stages A, B and C), Chemistry and structure, property variation with variation in monomer ratios, Properties and Industrial Applications	3
	15	Urea Formaldehyde, and Melamine Formaldehyde Resins, Properties and Industrial Applications	3
	16	Epoxy resins, Unsaturated polyester resins, Accelerators and curing behavious, Properties and Industrial Applications	3
	Fibers		**12**

V	17	Definition, Characteristics (Tex, Denier, tenacity), Classification, sources, aspect ratio, physical and chemical properties of fibers, conditions for fibers and fiber formations, fiber cross-section, processing of fibers, post fiber treatments and characterisations.	3
	18	Natural fibres-processing and characteristics of natural fibre-cotton, wool, silk, jute, properties and industrial applications. Cellulose fibers and modified cellulosic fibers -Rayon, regenerated cellulose fibres-viscose, Tencel???, cellulose acetate and triacetate-preparation and properties,	3
	19	Synthetic fibers- Manufacturing process and properties of-polyester,nylon,acrylic,. Comparison of synthetic fibre with natural fibers in terms of properties and application.	3
	20	Modification and Blending with natural and synthetic fibers, property modifications, textile fibers, fiber for high tech applications, advantages	3

References

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2. O. Olabisi, K. Adewale, Handbook of Thermoplastics, 2nd Edn, CRC Press, 2015
3. C. C. Ibeh, Thermoplastic Materials: Properties, Manufacturing Methods, and Applications, CRC Press, 2017.
4. U. W. Gedde, Thermosetting Polymers: Synthesis, Properties, and Applications, 2019.
5. Q. Guo, Thermosets: Structure, Properties, and Applications, 2018.
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7. A. Q. Stokes, Elastomers: Types, Properties and Applications, Nova Science Publishers, Inc.
8. W. Hofmann, W. Holzwarth, Rubber Technology Handbook, Hanser Publications, 2001.
9. J. G. Drobny, Elastomer Technology Handbook, CRC Press 2013.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	the student will be able to understand the basic principles of polymer chemistry, polymerization process, processing aspects and correlate the properties with molecular structure of the polymer	**U**	**PSO-1**
CO-2	the student will be able to identify the structural differences between different elastomers and correlate them with inherent properties, understand the variation in properties with additives, mixing, curing physical blending and chemical modifications	**R, U, Ap**	**PSO-7**

	and business to business concepts in the context of elastomer reclamation and recycling		
CO-3	the student will be able to identify the structural and compositional differences between different thermoplastics and correlate them with properties and uses, identify the correct additives, blending, molding and recycling strategies.	**R, U, Ap**	**PSO-5**
CO-4	the student will be able to identify thermoset structure and correlate their properties with different stages of their polymerization and compositional variations.	**R, U**	**PSO-1**
CO-5	the student will be able to identify fibers based on their unique features, differentiate between different fibers, methods of spinning and modification of properties by fiber treatments and blending leading to the innovation of new materials for industrial use and get an insight of the holistic aspects of materials science, engineering, research, development, and innovation within the fiber domain	**Ap, E**	**PSO-6**

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

Name of the Course: Commercial Polymers; Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	Course Outcomes	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	the student will be able to understand the basic principles of polymer chemistry, polymerization process, processing aspects and correlate the properties with molecular structure of the polymer	**1/1**	**U**	**C**	**L**	
CO-2	the student will be able to identify the structural differences between different elastomers and correlate them with inherent properties, understand the variation in properties with additives, mixing, curing physical blending and chemical modifications and business to business concepts in the context of elastomer reclamation and recycling	**1/7**	**R, U, Ap**	**C**	**L**	

CO-3	the student will be able to identify the structural and compositional differences between different thermoplastics and correlate them with properties and uses, identify the correct additives, blending, molding and recycling strategies.	**2/5**	**R, U, Ap**	**P,C**	**L**	
CO-4	the student will be able to identify thermoset structure and correlate their properties with different stages of their polymerization and compositional variations.	**2/1**	**R, U**	**P,C**	**L**	
CO-5	the student will be able to identify fibers based on their unique features, differentiate between different fibers, methods of spinning and modification of properties by fiber treatments and blending leading to the innovation of new materials for industrial use and get an insight of the holistic aspects of materials science, engineering, research, development, and innovation within the fiber domain	**6/6**	**Ap, E**	**P,C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO-1	**PSO-5**	**PSO-6**	**PSO-7**	**PO 1**	**PO 2**	**PO 6**
CO 1	**2**				**2**		
CO 2				**3**	**2**		
CO 3		**3**				**3**	
CO 4	**3**					**2**	
CO 5			**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		✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSEPOC202**				
Course Title	Polymers in Energy Applications				
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	-	Nil	4
Pre-requisites	Basic knowledge in energy storage cells. Basic knowledge on renewable and non-renewable energy resources.				
Course Summary	To learn the application of polymers in energy storage function, nano material fuel cells and polymer nanocomposites for renewable energy storage systems				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Energy Storage**	**12**
	1	Importance and need of energy storage, Modes of energy transmission	4
	2	Batteries, thermal, mechanical storage, hydrogen, pumped hydropower, flywheels	4
	3	Role of polymer in energy storage applications. environmental and sustainability issues.	4
II		**Energy Storage Devices Based on Polymers-I**	**12**
	4	Introduction, principal, methodology & working: photovoltaics, supercapacitors	4
	5	Lithium-ion batteries: PVAc based polymer blend electrolytes for lithium batteries	4
	6	Preparation of solid polymer electrolytes based batteries	4
III		**Energy Storage Devices Based on Polymers-II**	**12**
	7	Perovskite-type composite polymer electrolytes, PPO- type composite polymer electrolytes	4
	8	Sulfide-type polymer electrolytes, solid polymer electrolytes with ionic liquid	4
	9	Solid polymer electrolytes with cellulose	4
IV		**Fuel Cells**	**12**
	10	Hydrogen generation & storage, Fuel cells	3
	11	Principles and Nanomaterials design for; proton exchange membrane fuel cells (PEMFC), sulfonated poly (ether-ether ketone)s, sulfonated poly(aryl ether) for PEMFC and direct methanol fuel cell (DMFCs).	5

	12	Polymer composite membrane role (cation/anion/proton exchange membranes) in bio-electrochemical systems – construction and performance of MFCs.	4
V	**Polymer Nanocomposites for Renewable Energy Storage Systems**		**12**
	13	Solar cells: Types, functioning, mechanism, materials for solar cell and structure design	3
	14	Concept of solar cells with organic quantum dots, Quantum dots (polymer multiple & molecular multiple quantum dots)	3
	15	Polymer-inorganic hybrid solar cells, hybrid conjugated polymer-inorganic semiconductor composites	3
	16	Semiconducting polymer- based bulk hetero-junction solar cells, current trends and future status	3

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10. J. I. Kroschwitz, Encyclopedia of polymer science and technology, JohnWiley publishers, 2003.
11. H. F. Mark, Encyclopedia of polymer science and technology, JohnWiley & Sons publishers, 2013.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students familiarizing role of polymer in energy storage applications. environmental and sustainability issues.	**R,U**	**PSO-1**
CO-2	Students learns on principal, methodology & working of photovoltaics, supercapacitors, lithium-ion batteries. Learn	**U,Ap**	**PSO-1**

	about the manufacturing of fuel cells		
CO-3	Understand polymer properties related to energy components- fuel cells	**U**	**PSO-1**
CO-4	Explain to students on working process of lithium ion batteries and fuel cell	**U**	**PSO-1**
CO-5	Student understand on the Solar cells. Student gets an opportunity to analyse on current trends and future status	**U,An**	**PSO-8**

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

Name of the Course: Polymers in Energy Applications Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Students Familiarizing role of polymer in energy storage applications. environmental and sustainability issues.	**1/1**	**R, U**	**F, C**	**L**	
CO-2	Students learns on principal, methodology & working of photovoltaics, supercapacitors, lithium-ion batteries. Learn about the manufacturing of fuel cells	**3/1**	**U, Ap**	**F**	**L**	
CO-3	Understand polymer properties related to energy components- fuel cells	**6/1**	**U**	**M**	**L**	
CO-4	Explain to Students on working process of lithium ion batteries and fuel cell	**2/1**	**U**	**C**	**L**	
CO-5	Students understand about the Solar cells. Student gets an opportunity to analyse on current trends and future status	**2/8**	**U, An**	**F, C**	**L**	

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

Mapping of COs with PSOs and POs:

	PSO-1	PSO-8	PO-1	PO-3	PO-6	PO-2
CO 1	2	-	2	-	-	-

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

Correlation Levels:

Level	Correlation
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		✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3DSEPOC203**				
Course Title	Toxicology & Green Chemistry				
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	-	Nil	4
Pre-requisites	Foundational understanding of green chemistry Fundamentals of green synthesis				
Course Summary	This course provides students with an in-depth understanding toxicology of substances and give an insight into green technology adopted for clean environment				

Detailed syllabus:

Module	Unit	Content	Hours
I		**Introduction to Toxicology**	**12**
	1	Introduction- concept of Toxicology, chronic and acute effects, toxic chemicals in environment- Air, Water & Soil,	3
	2	Dose response concept- LD 50, LC 50	2
	3	Carcinogens-general aspects. Hazards from food additives.	2
	4	Toxicology of pesticides, insecticides and organometallic compounds	2
II		**Toxicological Effects**	**12**
	5	Toxicological effects- General characteristics, biochemical, physiological, reversible and irreversible effects. Effect on the immune system. Detoxification. Impact of toxic chemicals on enzymes.	4
	6	Biochemical effects of As, Pb, Cd, Hg, CO, oxidesnitrogen & Sulphur, ozone and PAN	4
	7	Solutions to environmental problems- Prevention of pollution and design for eco-friendly environment.	1
III		**Green Technology- Introduction**	**12**
	8	Introduction Definition and concepts, Green technology, green energy, green infrastructure, green economy and green chemistry.	2
	9	Green technologies in historical and contemporary perspectives. Successful green technologies: WindTurbines, solar panel, 3 R's of green technology.	3
	10	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

IV		**Introduction to Green Chemistry**	**12**
	11	Need and goal of green chemistry, Twelve principles ofgreen chemistry	4
	12	Concept of atom economy and its calculations	1
	13	Tools of Green Chemistry- Green starting materials, green reagents, green reactions, green methodology and green chemical products	2
	14	Obstacles and Progress of Green Chemistry	2
V		**Applications of Green Chemistry**	**12**
	15	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
	16	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	4
	17	Importance of green chemistry in day to day life, green chemistry in sustainable development	1

References

1. B. Pani, Text Book of Environmental Chemistry, I. K. International Publishing House Pvt. Ltd., 2013.
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8. S. L. Arceivala, Green Technologies: For a Better Future, Mc-Graw Hill Publication, 2014.

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 factorsinfluencing toxicity such as route of exposure and duration of exposure..	**U**	**PSO-1**
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, An**	**PSO-8**
CO3	Enable to identify and assess the hazards associated with various chemicals, including carcinogens, mutagens, teratogens, and other toxicants, using principles of risk assessment and toxicological testing.	**An**	**PSO-3**
CO4	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**	**PSO-1**
CO5	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**	**PSO-5**

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

Name of the Course: Toxicology & Green Chemistry; Credits: 4:0:0 (Lecture:Tutorial :Practical)

CO No.	Course Outcomes	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	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..	**1/1**	U	**C**	**L**	
CO-2	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	**2/8**	U, An	**C**	**L**	

	environmental and human health.					
CO-3	Enable to identify and assess the hazards associated with various chemicals, including carcinogens, mutagens, teratogens, and other toxicants, using principles of risk assessment and toxicological testing.	**2/3**	An	**P,C**	**L**	
CO-4	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.	**2/1**	U	**P,C**	**L**	
CO-5	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.	**6/5**	Ap	**P, C**	**L**	

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

Mapping of COs with PSOs and POs:

	PSO-1	PSO-3	PSO-5	PSO-8	PO 1	PO 2	PO 6
CO 1	**2**				**2**		
CO 2				**3**		**2**	
CO 3		**3**				**3**	
CO 4	**1**					**2**	
CO 5			**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		√		√

Discipline	POLYMER CHEMISTRY				
Course Code	**UK3VACPOC201**				
Course Title	Biofriendly Polymers				
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	-	Nil	3 h
Pre-requisites	A basic idea of polymers				
Course Summary	This course provides an understanding of history and basic concepts of polymers, Natural and synthetic polymers, Biopolymers and Biodegradable polymers, Polymer degradation and stability and polymers in everyday life.				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**History and Basic Concepts of Polymers**	**9**
	1	Discovery of some Polymers,	1
	2	Monomer,Oligomer, Polymer, Molecular weight (Number average, Weight average), Classification of Polymers based on origin, composition, structure, molecular forces,	4
	3	Modes of polymerization.	4
II		**Natural and Synthetic Polymers**	**9**
	4	Commercially important Natural Polymers – Starch, Cellulose, Rubber- Preparation, Properties and uses.	3
	5	Commercially important Synthetic Polymers –Nylon, Polyethylene, PVC, Teflon, PET,	3
	6	Bakelite, Glyptal, Epoxy Resin - Preparation, Properties and uses.	3
III		**Biopolymers and Biodegradable Polymers**	**9**
	7	Properties of Biopolymers and Biodegradable polymers, Examples and uses of Biopolymers	3
	8	Protein, Cellulose, Starch, Collagen, Examples and uses of Biodegradable Polymers – Poly glycolic acid (PGA),	3
	9	Poly Lactic acid (PLA), Poly caprolactone (PCL), Nylon-2-Nylon-6.	3
IV		**Polymer Degradtion and stability**	**9**
	10	Factors causing degradation- heat, mechanical energy, radiation, chemicals-	2
	11	Thermal degradation, Photodegradation, Mechanical degradation,	2
	12	Degradation by high energy radiation and ultrasound and Degradation by chemicals,	2
	13	Factors affecting polymer stability- Chemical structure and composition.	2

	14	Plastic Recycling codes, Microplastics and related issues	1
V		**Methods to Develop and Assess Biodegradability**	**9**
	15	Development of relative starch technology	3
	16	Polyethylene/starch film, reprocessing polyethylene/cornstarch film scrap.	3
	17	Description of current test methods -screening test for ready biodegradability.	3

References

1. B. Ghanbarzadeh, H. Almasi, Biodegradable Polymers in Biodegradation - Life of Science, R. Chamy, F. Rosenkranz (Eds), IntechOpen, 2013.
2. M. Palencia, T. A. Lerma, V. Garcés, M. A. Mora, J. M. Martínez, S. L. Palencia, Ecofriendly functional Polymers, Elsevier, 2021.
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4. G. J. L. Griffin (ed.), Chemistry & Technology of Biodegradable Polymers, Springer, 2012.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Develop understanding on biofriendly polymers.	**U**	**1**
CO-2	Will understand the applications of polymers in everyday life.	**Ap**	**5**
CO-3	Will identify the polymers used in daily life activities	**Ap**	**5**
CO-4	Will develop interest to know more about the structure of various polymers	**E.An**	**1,5**
CO-5	Will assess bio-degradability of polymers	**Ap**	**5**

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

Name of the Course: Biofriendly Polymers Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understanding of rubber materials	**1/1**		**C**		
2	Knowledge of latex processing techniques	**1/5**		**C,P**		

3	Knowledge of rubber processing techniques	**1/5**		**C,P**		
4	Characterisation of rubber compounds and products	**1/1,5**		**P**		
5	Quality control and assurance	**2,8/5**		**C**		

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

Mapping of COs with PSOs and POs :

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

.

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4DSCPOC201**				
Course Title	Inorganic Chemistry-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	Basics underastanding of periodic table and anlytical chemistry				
Course Summary	This course offers a comprehensive study of compounds of s and p block elements, lanthanides and actinides, inter halogen comounds and noble gases. Additionally, it includes practical experiments in inorganic qualitative analysis intented to provide students with hands-on experience in the laboratory.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Main Group Elements(S & P block)**	**6**
	1	S & P block elements-Electronic configuration & general properties	2
	2	Hydrides and their classification - ionic, covalent and interstitial	1
	3	Study of the following compounds with emphasis on structure, preparation and properties. Boric acid and borates, carboranes and graphitic compounds, oxides and oxoacids of nitrogen and phosphorus, oxyacids of halogens.	3
II		**Lanthanides and Actinides**	**6**
	4	Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).	6
III		**Compounds of Transition elements**	**6**
	5	General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states	3
	6	Difference between the first, second and third transition series.	3
IV		**Interhalogen compounds and Noble gases**	**6**
	7	Preparation and properties of inter halogen compounds and pseudo halogens.	3
	8	Noble gases - uses xenon compounds – preparation, properties, structure and hybridization in xenon fluorides.	3
V		**Principles of Qualitative Analysis**	**6**

	9	Introduction to Qualitative Analysis: Definition and significance of qualitative analysis in chemistry. Basic principles of qualitative analysis: detection and identification of ions. Importance of qualitative analysis in research, industry and environmental monitoring.	1
	10	Solubility Equilibria in Qualitative Analysis: Solubility product (K_{sp}) 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
	11	Identification of Cations in Qualitative Analysis: Systematic analysis of cations: principles, procedures and chemistry Identification of cations: Lead, Copper, Bismuth, Cadmium, Tin, Antimony, Ferrous, Ferric ions, Aluminium, Chromium, Zinc, Manganese, Cobalt, Nickel, Calcium, Strontium, Barium, Magnesium, Potassium and Ammonium ions/radicals.	2
	12	Identification of Anions in Qualitative Analysis: Systematic analysis of anions: principles, procedures and chemistry Identification anions: Carbonate, Sulphide, Nitrite, Nitrate, Fluoride, Chloride, Bromide, Iodide, Borate, Acetate, Oxalate, Chromate, Phosphate and Sulphate anions.	1

Inorganic Chemistry I Practical 60 Hrs

Module	Content	Hrs.
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.	15
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.	15
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)**	30

References.

14. M. C. Day and Selbin, Theoretical Inorganic Chemistry, East west Press, 2 nd Edn., 2008
15. J. D. Lee, Concise Inorganic Chemistry, Wiley India Pvt. Ltd., 5th Edn, 2008.

16. B. R. Puri L R. Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, New Delhi, 5th Edn, 2010.
17. A. I. Vogel, A text book of Qualitative Analysis including semi micro methods, Longmans, 7th Edn, 1945.
18. E. S. Gilreath, Qualitative Analysis using semi micro method, Mc Graw Hill, 1954.
19. A. I. Vogel, A text book of Qualitative Inorganic Analysis, Longmans, 7th Edn, 2008.
20. J. E. House, Inorganic Chemistry, Academic press, 2008.
21. 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	Correlate and predict general properties of s and p block elements based on their electronic configuration and realise application of s and p block elements	**A**	**PSO 1**
CO-2	Understand the occurrence, properties and separation of lanthanides and actinides	**U**	**PSO 1**
CO-3	Discuss the electronic configuration and related properties of transition elements	**U**	**PSO 2**
CO-4	Understand chemistry of noble gas and describe various types of halogen compounds	**U, Ap**	**PSO 1**
CO-5	Enhance problem-solving skills by providing practical insights into qualitative analysis applications in various industries	**Ap**	**PSO 3**
CO-6	Proficiency in qualitative inorganic analysis techniques, enabling to accurately identify cations and anions in complex mixtures	**Ap**	**PSO 3, 4, 6, 7**

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

Name of the Course: Inorganic Chemistry- I Credits: 2:0:2 (Lecture : Tutorial : Practical)

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

1	Correlate and predict general properties of s and p block elements based on their electronic configuration	**1/1**	**A**	**C**	**L**	
2	Understand the occurrence, properties and separation of lanthanides and actinides.	**1/1**	**U**	**C**	**L**	
3	Discuss the electronic configuration and related properties of transition elements.	**1/2**	**U**	**C**	**L**	
4	Understand chemistry of noble gas and describe various types of halogen compounds	**1/1**	**U, Ap**	**C**	**L**	
5	Enhance problem-solving skills by providing practical insights into qualitative analysis applications in various industries.	**2/3**	**Ap**	**C, P**	**L**	
6	Proficiency in qualitative inorganic analysis techniques, enabling to accurately identify cations and anions in complex mixtures.	**2, 3, 6, 8/3, 4, 6, 7**	**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 6**	**PSO 7**	**PO1**	**PO2**	**PO3**	**PO4**	**PO6**	**PO7**
CO 1	2	-	-	-	-	-	2					
CO 2	2	-	-	-	-	-	2					
CO 3	-	2	-	-	-	-	2					

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

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4DSCPOC202**				
Course Title	Bonding, Reactions and Degradation of Polymers				
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. Basic understanding of chemical bonding 2. Basic knowledge in polymer chemistry				
Course Summary	To learn about bonding, synthesis and structure of polymers. To learn about the reactions associated with degradation of polymers. To get knowledge about rheological properties of polymers.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Bonding in Polymers**	**9**
	1	Chemical bonds - Ionic bonds, Covalent bonds, Metallic bonds, Hydrogen bonds, Dipole forces, Induction forces, van der Waals forces, Primary structure, Secondary structure, Cross links, Configuration and Conformation, Crystalline and Amorphous polymers, Inter chain attractive forces.	4
	2	Tacticity in Polymer- Isotactic, Syndiotactic, Atactic. Cis-trans Isomerism in Polymer, Functionality in polymer.	3
	3	Crystallinity in polymers, Factors affecting Crystallizability: Polarity, Effect of bulky groups, Degree of crystallinity.	2
II		**Polymer reactions I**	**9**
	4	Criteria for polymer synthesis, Addition and Condensation polymerization, Chain growth, Ring opening, Step polymerization. Polymerization techniques: Bulk, Suspension, Emulsion and Solution processes.	4
	5	Concept of functionality, Carother's equation and its applications in polymerization reactions, Kinetics of step growth polymerization and Chain growth polymerization, Ionic polymerization, Effect of gegen ions, Reactivity ratios, Zeigler-Natta catalyst and Coordination polymerization.	5
III		**Polymer reactions II**	**9**
	6	Introduction to preparation, structure, properties and applications of the following polymers: polyolefins, polystyrene and its copolymers, poly (vinyl chloride), poly (vinyl acetate) and related polymers.	3

	7	Brief introduction to preparation, structure, properties and applications of the following polymers: Phenol formaldehyde resins, Melamine-formaldehyde resins, Polyurethanes, Silicones, and Epoxides.	3
	8	Brief introduction to preparation, structure, properties and applications of the following polymers: Acrylic polymers, Fluoropolymers, Aliphatic polyamides, Saturated polyesters.	3
IV		**Polymer solution**	**9**
	9	Polymer solutions, Solubility parameter, Viscosity and Polymer processing, Rheological properties of fluids, shear stress in polymers, Newtonian & non-Newtonian flow, Polymer melt viscosities, Flow in channels, Simple shear flow, Melt-flow index, Weissenberg effect.	4
	10	The elastic and viscoelastic state of polymers, Viscoelasticity, Viscoelastic models: Maxwell model, Voigt-Kelvin model (basic idea)	2
	11	Types of fluid & rheological models, Rheological measurements by capillary, Parallel plate and cone viscometers, Simple elongational flow and its significance, Dynamic flow behaviour, Time dependent fluid behaviour.	3
V		**Polymer degradation**	**9**
	12	Introduction to degradation, Classification of degradation based on Pattern of degradation-Random degradation, Side chain degradation, Chain end degradation. Cause of degradation- Thermal degradation, Oxidative degradation, Degradation by radiation, Mechanical degradation, Chemical degradation, Biological degradation.	4
	13	Degradation pattern and mechanisms of Polyolefins, PVC, Polyamides, PMMA, Cellulose, Polyacrylonitrile, Polystyrene, PET.	3
	14	Degradation of Poly urethane, Natural rubber and SBR.	2

Bonding, Reactions and Degradation of Polymers Practical: 30 hrs

Module	Unit	**Content**	
I		**Synthesis and Degradation experiments**	**30**
	1	Synthesis of Phenol formaldehyde resin	2
	2	Synthesis of urea formaldehyde resin	2
	4	Synthesis of aniline formaldehyde resin	2
	3	Synthesis of polyacrylamide by free radical polymerization	3
	4	Synthesis of polystyrene by pearl polymerization	3
	5	Suspension polymerization of styrene/MMA	2
	6	Preparation of Poly (vinyl butyral)	2
	7	Biodegradation of polymers	2
	8	Thermal and photo degradation of polymer under various conditions	2
	10	Evaluate chemical degradation of condensation polymers	2
	11	Determine environmental stress cracking resistance of polymers	2
	12	Visit to analytical laboratories or industries	6

References

1. F. Mohammad, Specialty Polymers: Materials and Applications, I. K. International Publishing House Pvt. Ltd, 2007.
2. A. J. Domb, Handbook of Biodegradable Polymer, Gordon and Breach Science Publishers, 1997.
3. G. S. Misra, Introductory Polymer Chemistry, New Age International, New Delhi.
4. M. P. Steves, Polymer chemistry-An introduction, 3rd edition, Oxford University Press, 1999.
5. F. W. Billmeyer Jr., Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.
6. W. L. Hawkins, Polymer Degradation and Stabilization, SpringerLink, 1984.
7. G. J. L Griffin (Ed.), Chemistry & Technology of Biodegradable Polymers. Springer.
8. P. L. Nayak, Polymer Science, Kalyani Publishers, New Delhi, 2012.
9. R. J. Young & P. A. Lovell, Introduction to polymers, Chapman & Hall, London. Wiley, 1991.
10. F. Rodrignek, Principles of Polymer Systems, McGraw Hill, 1981.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Discuss about various types of bonds and structural aspects of polymers and composites.	**U**	**PSO1**
CO-2	Understand about different polymerization methods.	**U**	**PSO5**
CO-3	Understand about polymerization of commercially important polymers.	**U, Ap**	**PSO5**
CO-4	Understand different rheological concepts and theories related to polymer in solution.	**U, Ap**	**PSO5**
CO-5	Discuss about different polymer degradation processes.	**U, Ap**	**PSO1**

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

Name of the Course: Bonding, Reactions and Degradation of Polymers Credits: 3:0:1 (Lecture : Tutorial : Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Discuss about various types of	**PO1/PSO1**	**U**	**C**	**L**	

	bonds and structural aspects of polymers and composites.					
CO-2	Understand about different polymerization methods.	**PO2/PSO5**	**U**	**C**	**L**	
CO-3	Understand about polymerization of commercially important polymers.	**PO1/PSO5**	**U, Ap**	**C**	**L**	**P**
CO-4	Understand different rheological concepts and theories related to polymer in solution.	**PO1/PSO5**	**U, Ap**	**C**	**L**	**P**
CO-5	Discuss about different polymer degradation processes.	**PO1/PSO1**	**U, Ap**	**C**	**L**	**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**
CO1	2	-	-	-	1	2	-	-	-	1
CO2	1	-	-	-	2	2	-	-	-	1
CO3	1	-	-	-	2	2	1	-	-	-

CO 4	1	-	-	-	2	2	-	-	-	-
CO 5	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
- Project Evaluation
- Final Exam
- Industrial visit and report

Mapping of COs to Assessment Rubrics :

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

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4DSCPOC203**				
Course Title	Physical 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	Basic concepts of Physical Chemistry				
Course Summary	Course encompasses the study of solid, liquid, and gaseous states, as well as the electrical properties exhibited by these states. Emphasis is placed on understanding the underlying principles governing these properties and their applications in various fields.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Gaseous State**	**9**
	1	Kinetic Theory of Gases: Postulates, Types of Molecular Velocities (average, most probable and RMS), Formulas and their Inter Relations. Maxwell Boltzmann Distribution. Statement and Explanation (No derivation). Effect of Temperature.	2
	2	Collision Properties. Collision Diameter, Collision Number, Collision Frequency and Mean Free Path.	1
	3	Ideal Gas Equation. Behaviour of Real Gases. Deviation of Real Gases from Ideal Behaviour. Compressibility Factor.	2
	4	Boyle Temperature- Van der Waals' Equation of State- Derivation and Importance. Virial Equation of State.	2
	5	Critical Phenomena-Isotherms of CO_2. Critical Constants Continuity of State.. Relation between Critical Constants and Van der Waals Constants. Liquefaction of Gases-Linde's and Claude's Process	2
II		**Dilute Solutions**	**9**
	6	Dilute solutions: Molality, Molarity, Normality and Mole Fraction.	1
	7	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	5

	8	Determination of Molecular Mass of Solute by Beckmann Method. Rast Method and Cooling Curve Method. Abnormal Molecular Mass-Van't Hoff Factor. Determination of Degree of Dissociation and Association	3
III		**Binary Liquid System**	**9**
	9	Liquid-Liquid system: - Completely Miscible, Ideal and Non-Ideal Mixtures.	1
	10	Raoult's Law, Vapour Pressure - Composition, Temperature-Composition Curves	1
	11	Fractional Distillation, Deviation from Raoult's Law	1
	12	Azeotropic Mixtures, Partially Miscible Liquid System, Critical Solution Temperature, Conjugate Layers, Example for Upper, Lower and Upper cum Lower CST.	2
	13	Immiscible Liquid Pairs. Theory of Steam Distillation	1
	14	Distribution Law - Its Thermodynamic Derivation. Limitations of Distribution Law.	1
	15	Applications of Distribution Law to the Study of Association and Dissociation of Molecules. Solvent Extraction. Equilibrium Constant of $KI + I_2 \rightarrow KI_3$.	2
IV		**Electromotive Force**	**9**
	16	Electrochemical Cells (brief explanation). Types of Electrodes – Metallic Electrodes, Gas Electrodes, Anion Reversible Electrodes and Redox Electrodes	2
	17	Reference Electrodes – Standard Hydrogen and Calomel Electrodes. Electrode Reactions and Cell Reactions	1
	18	Derivation of Nernst Equation for Electrode Potential and Cell Potential. Gibbs-Helmholtz Equation and EMF of a Cell. Calculation of ΔG, ΔH, ΔS and Equilibrium Constant from EMF Data	2
	19	Fuel Cells: Principle, H_2-O_2 and Hydrocarbon-O_2 Fuel Cells. Over Voltage.	2
	20	Applications of Potential Measurements: Potentiometric Titrations of Acid – Base and Redox Reactions.	2
V		**Electrical Conductance**	**9**
	21	Conductance: Arrhenius Theory. Variation of Conductance with Dilution of Strong and Weak Electrolyte. Debye- Huckel Theory of Inter Ionic Attraction. Debye–Huckel–Onsager Equation (only qualitative treatment). Wien Effect. Debye–Falkenhagen Effect. Walden's rule	4
	22	Activity and Activity Coefficient of Electrolytes. Kohlrausch's Law and its Application.Ionic Mobilities: Transference Number and its Determination	3

		by Hittorff's and Moving Boundary Methods. Abnormal Transference Number.	
	23	Applications of Conductivity Measurements: Conductometric Titrations involving Strong Acid – Strong Base, Strong Acid – Weak Base, Weak Acid - Strong Base, Weak Acid – Weak Base and Precipitation.	2

Physical Chemistry II Practicals - 30Hrs

Module	Unit	Content	Hrs
I		**Phenol-water (Binary liquid systems)**	
	1	Critical solution temperature of phenol –water system	5
	2	Influence of KCl (impurity) on the miscibility temperature of phenol-water system. Determination of concentration of given KCl solution	5
II		**Conductometry**	
	1	Determination of cell constant	4
	2	Conductometric titration of NaOH using HCl	4
III		**Potentiometry**	
	1	Potentiometric titration of Fe^{2+} *versus* $Cr_2O_7^{2-}$	4
	2	Potentiometric titration of $KMnO_4$ *versus* KI	4
	3	Potentiometric titration of HCl versus NaOH using Quinhydrone electrode.	4

References:

1. S. Glasstone and G. N. Lewis, Elementary Physical Chemistry, Longman, 1963.
2. N. Kundu and S. K. Jain, Physical Chemistry, S. Chand, 1998.
3. K. L. Kapoor, Elements of Physical Chemistry, Macmillan, 2012.
4. G. M. Barrow, Physical Chemistry, McGraw-Hill, 1996.
5. G. W. Castellan, Physical Chemistry, Narosa, 2015.
6. V. D. Athawal, Experimental Physical Chemistry, New Age International,1st edition, 2001
7. J. B. Yadav, Advanced Practical Physical Chemistry Goel Publishing House, Meerut., 2015
8. R. C. Das and Behera, Experimental Physical Chemistry, Tata McGraw Hill,1984

Course Outcomes

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

CO-1	Identify, compare and explain the properties and behaviour of ideal and real gases, knowing kinetic theory of gases and different types of molecular velocities and collision properties.	**U**	**1**
CO-2	Discussion of Colligative properties and determination of molarmass of unknown solute.	**U, Ap**	**1**
CO-3	Discussion of Azeotropic Mixtures, critical solution temperature, distribution law and its applications	**Ap**	**2**
CO-4	Develop skill in doing potentiometric titration,conductometric titration and CST	**Ap**	**3, 4**
CO-5	Understand the concept of Activity, Kohlrausch's Law and its Application	**U, Ap**	**2**

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

Name of the Course: Physical Chemistry II Credits: 3:0:1 (Lecture : Tutorial : Practical)

CO No.	CO	PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Identify, compare and explain the properties and behaviour of ideal and real gases, knowing kinetic theory of gases and different types of molecular velocities and collision properties.	**1/1**	**U**	**C**	**L**	
2	Discussion of Colligative properties and determination of molarmass of unknown solute.	**1/2**	**U, Ap**	**P**	**L**	
3	Discussion of Azeotropic Mixtures, critical solution temperature, distribution law and its applications	**1/2**	**Ap**	**C**	**L**	
4	Develop skill in doing potentiometric titration,conductometric titration and CST	**2/4**	**Ap**	**C**		**P**

5	Understand the concept of Activity, Kohlrausch's Law and its Application	**1/1, 2**	**U, Ap**	**C**	**L**	

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**
CO 1	2		-	-	-	2	-	-
CO 2		2	-	-	-	2	-	-
CO 3		2	-	-	-	2	-	-
CO 4			2-	2	-	-	2	-
CO 5	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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4DSCPOC204**				
Course Title	Industrial Polymers and Processes				
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	Basic understanding of Polymer chemistry and materials science concepts.				
Course Summary	1. Understanding the fundamental concepts of industrial polymers, including their classification, synthesis mechanisms, and key properties. 2. Analyze the role of cross-linking techniques in modifying polymer properties and their applications. 3. Apply compounding techniques to enhance polymer properties and characterize compounded materials through practical experiments.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Polymer based Industries**	**9**
	1	Industrial Polymers - Definition and classification, Importance and Significance. Historical Perspective and Key Milestones in Polymer Science	3
	2	Basic Concepts: Monomers, Polymerization Mechanisms, Polymer Structures. Polymerization Techniques: Addition, Condensation, and Copolymerization.	2
	3	Role of Catalysts, Initiators and Reaction Conditions in Polymer Synthesis	1
	4	Mechanical Properties: Strength, Toughness, Elasticity. Thermal Properties: Glass Transition Temperature, Melting Point, Thermal Conductivity. Chemical Properties: Stability, Reactivity, Solubility.	3
II		**Cross linking techniques**	**9**
	5	Definition and Significance of Cross-linking in Polymers	1
	6	Chemical and Physical Mechanisms of Cross-Linking. Factors Influencing Cross-Linking. Chemical Cross-Linking- Vulcanization (Sulphur and Peroxide)	3
	7	Mechanisms of Radiation-Induced Cross-Linking. Radiation Curing Methods: UV, Electron Beam, Gamma Irradiation	3
	8	Physical Cross-Linking- Thermosetting and Thermoplastic Polymers	2
III		**Compounding Techniques – 1**	**9**

	9	Definition and Significance of Polymer Compounding.	1
	10	Compounding Additives: Classification Based on Functions - Fillers, Reinforcements, Plasticizers, Stabilizers, Colorants, etc.	3
	11	Principles of Polymer Compounding Process Optimization: Formulation Design, Material Selection, Mixing Techniques, and Quality Control. Role of Additives in Enhancing Polymer Properties.	3
	12	Polymer Compounded Materials - Rheological, Mechanical, Thermal, and Chemical Characterization	2
IV		**Moulding Techniques - 1**	**9**
	13	Definition and Significance of Moulding in Polymer Processing. Introduction to Different Types of Moulding Techniques: Injection Moulding, Compression Moulding, Transfer Moulding, and Blow Moulding. Factors Influencing Moulding Processes	2
	14	Principles, Advantages, Application and Limitations of Injection Moulding. Materials for Injection Moulding- Thermoplastics High-Performance Polymers and Engineering Plastics.	3
	15	Compression Moulding- Principles and Process Steps- Advantages, Limitations, and Applications of Compression Moulding. Materials Suitable for Compression Moulding and their Properties- Thermosetting Polymers, Phenolic Resins, FRC.	3
	16	Transfer Moulding- Introduction and Application. Comparison with Injection and Compression Moulding Techniques. Importance of Moulding Techniques in Various Industries. Advancements and Future Trends in Moulding Technologies.	2
V		**Techniques in Tyre Manufacturing**	**9**
	17	Historical Development of Polymer-Based Tyre Materials. Raw Materials and Compounding- Types of Rubber Used, Chemical Structure and Properties of Rubber Polymers	3
	18	Types of Fillers and Reinforcement Materials (Carbon Black, Silica, etc). Rubber Compounding Techniques and Formulations	3
	19	Role of Additives (Antioxidants, Plasticizers, etc.) in Rubber Formulations.	1
	20	Vulcanization and Curing: Principles of Curing and Vulcanization. Mechanisms of Vulcanization and Cross-Linking in Rubber. Influence of Curing Agents and Accelerators on Tyre Properties.	2

Industrial Polymers and Processes- Practical 30Hrs

Module	**Unit**	**Content**	**Hrs**
I	1	End group analysis- Molecular weight determination, vinyl content, carboxyl, epoxy, acetyl, amino and hydroxyl.	3
	2	Acid value, iodine number and saponification value.	2

	3	Identification of unknown polymer using heating, burning, solubility.	1
	4	Confirmatory chemical tests for Identification of unknown polymer.	2
	5	Quantitative estimation of the basic raw materials and auxiliaries used in polymer such as phenol, urea, formaldehyde	2
	6	Determination of Moisture Content in plastics materials.	2
	7	Determination of Ash Content in plastics materials	2
	8	Determination of Filler content in plastics materials.	2
	9	Determination of Melt flow index of plastics materials.	2
	10	Determination of Optical properties of plastics materials	2
	11	Determination of Thermal Properties of plastics materials.	2
	12	Determination of Electrical Properties of plastics materials.	2
	13	Study of Weathering properties of plastic materials.	2
	14	Determination of Density of plastic materials.	1
	15	Determination of chlorine content of PVC.	2
	16	Determination of crosslink density from swelling method	1

References

1. P. J. Flory, Principles of Polymer Chemistry, 1953, Cornell University Press.
2. J. E. Mark, N. M. Bikales, Encyclopedia of Polymer Science and Engineering 2nd Edition, John Wiley & Sons, 1996.
3. J. -P. Fouassier, J. F. Rabek, Radiation Curing in Polymer Science and Technology: Fundamentals and Methods, Elsevier, 1993.
4. L. H. Sperling, Introduction to Physical Polymer Science, 4th Edition, John Wiley & Sons, 2006.
5. T. A. Osswald, and J. P. Hernández-Ortiz, Polymer Processing: Modeling and Simulation, Hanser Publishers, 2006.
6. B. Rodgers, Rubber Compounding: Chemistry and Applications, Marcel Dekker, 2004.
7. R. P. Brown. Handbook of Plastics Test Methods, 3rd Edition, Longman Scientific and Technical, 1989.
8. J. Urbanski, Handbook of Analysis of Synthetic Polymers and Plastics, 1st Edition, Prentice Hall Europe, 1977.
9. V. Shah. Handbook of Plastics Testing Technology, 1st Edition. Wiley Inter science, 1998.
10. D. Braun, Simple Methods for Identification of Plastics, 5th Edition, Hanser Publications, 2013.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the basics of polymer science and assess the influence of catalysts and reaction conditions in polymer synthesis.	**U**	**1, 2**
CO-2	Understand the mechanical and thermal properties of polymers, and analyze their chemical stability and reactivity for industrial applications.	**U, An**	**1, 5**
CO-3	Recognize the significance of cross-linking in polymer modification and processing. Learn the factors influencing cross-linking, including the role of cross-linking agents and conditions.	**U,R**	**1, 5**
CO-4	Understand the basic concepts of polymer compounding and role of additives in enhancing the properties of polymers for various applications.	**U, Ap**	**1, 6**
CO-5	Gain basic idea about different moulding techniques in polymer processing and its pivotal role in various industries. Able to select materials and formulation design for specific industrial applications	**U, Ap**	**6, 7**
CO-6	Enable students to adapt to emerging developments in the field of polymer processing. Understand the fundamentals of tyre manufacturing, and the role of additives and reinforcing agents in tyre industries. Analyse the processes of vulcanization and curing in rubber	**E, U, An**	**1, 6**

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

Name of the Course: Industrial Polymers and Processes Credits: 3:0:1 (Lecture : Tutorial : Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L) / Tutorial (T)	Practical (P)
1	Understand the basics of polymer science and assess the influence of catalysts and	**1/1, 2**	**U**	**C**	**L**	

	reaction conditions in polymer synthesis.					
2	Understand the mechanical and thermal properties of polymers, and analyze their chemical stability and reactivity for industrial applications.	**1/1, 5**	**U, An**	**C**	**L**	
3	Recognize the significance of cross-linking in polymer modification and processing. Learn the factors influencing cross-linking, including the role of cross-linking agents and conditions.	**1/1, 5**	**U, R**	**C**	**L**	
4	Understand the basic concepts of polymer compounding and role of additives in enhancing the properties of polymers for various applications.	**1/1, 6**	**U, Ap**	**C**	**L**	
5	Gain basic idea about different moulding techniques in polymer processing and its pivotal role in various industries. Able to select materials and formulation design for specific industrial applications.	**1, 2/6, 7**	**U, Ap**	**C**	**L**	
6	Enable students to adapt to emerging developments in the field of polymer processing. Understand the fundamentals of tyre manufacturing, and the role of additives and reinforcing agents in tyre industries. Analyse the processes of vulcanization and curing in rubber.	**1, 2/1, 6**	**E, U, An**	**C**	**L**	**P**

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

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	-	-	-	-	-	-	3	-	-	-	-	-	-	-
CO 2	2	-	-	-	2	-	-	-	3	-	-	-	-	-	-	-
CO 3	2	-	-	-	2	-	-	-	3	-	-	-	-	-	-	-
CO 4	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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4DSEPOC201**				
Course Title	Latex and Rubber Processing Technology				
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	Basic understading of Polymer Chemistry				
Course Summary	To impart the basic concepts of latex and rubber compounding, principles of compounding and vulcanization.To design various recipes to meet vulcanisate properties. it includes practical experiments in LATEX analysis and providing students with hands-on experience in the laboratory.				

DETAILED SYLLABUS:

MODULE	UNIT	CONTENT	HRS
I		**Principles of latex compounding**	**8**
	1	Introduction of natural rubber latex, Classification of latices	2
	2	Concentration of latex, preservation of latex concentrate	2
	3	Latex compounding ingredients-vulcanizing agents, accelerators, activators, fillers, surface active agents, antioxidants, heat sensitizing agents and dispersing agents, thickeners, gelling agents, wetting agents etc.	2
	4	Preparation of compounding ingredients-solution, emulsion and dispersion, formulation of latex product	2
II		**Processing of latex products**	**10**
	5	Compounding of latex-machinery-ball mill-dipping tank- formers	3
	6	Introduction to various dipped goods-dipping process	2
	7	Methods of dipping- straight dipping , coagulant dipping,merits and demerits	2
	8	After treatment of latex deposits-drying, surface treatment, bleaching, chlorination, vulcanization and stripping	3
III		**Principles of Rubber compounding**	**9**
	9	Introduction to rubber compounding	2
	10	Additives for rubber compounding-base polymer, thickening agents,wetting agents, vulcanizing agents	2
	11	accelerators for cross linking reactions, activators and retarders	2

	12	Reinforcing fillers, inert fillers, softeners, dispersing agents,processing aids, antidegradants, colouring agents, special additives	3
IV		**Rubber Processing**	**9**
	13	Selection of ingredients, formulation of additives	2
	14	Raw rubber processing, steps and stages of compound development and product development	3
	15	Mixing procedure	4
V		**Rubber compounding techniques**	**9**
	16	Different molding techniques for rubber compounding- two roll mixing mill, mastication and master batch	3
	17	Internal mixers, continues and automatic high speed mixing,	2
	18	Compression molding, transfer molding, injection molding	2
	19	Theory of sulfur vulcanization	2

Latex and Rubber Processing Technology Practical – 30 Hrs

Module	Unit	Content	Hrs
I	1	• Estimation of Dry Rubber Content of Latex(DRC) • Estimation of Total Solid Content of Latex(TSC) • Preparation of dispersions of solid latex compounding • Preparation of emulsions of liquid compounding ingredients • Preparation of latex compounding for household gloves, balloons and finger caps	30

References

1. D. C. Blackley, High polymer Lattices, Vol 1, Springer Netherlands, 1997
2. D. C. Blackley, High polymer Lattices, Vol 2, Springer Netherlands, 1997
3. D. C. Blackley, High polymer Lattices, Vol 3, Springer Netherlands, 1997
4. R. J. Noble, Latex in industry, Rubber age Palmerton, New York,.2022.
5. W. Hofman, Rubber Technology handbook, Oxford University press, 2022.
6. C. M. Blow, Rubber technology and manufacture, Butterworth- Hainemann, 2022.
7. M. Morton, Rubber Technology, Springer,2022.
8. Training Manual RTI RRII Kottayam.
9. SITTTR lab manual

Course Outcomes

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

CO-1	Understanding the principles of latex compounding methods and how the compounding ingredients are added to form desired products.	**U**	**PSO-1**
CO-2	Gain an understanding of natural rubber latex processing techniques, including ball milling, dipping process to form the desired product.	**R, U**	**PSO -1**
CO-3	To understand the principles of rubber compounding and describe the additives for rubber compounding and explain the functions of additives used for rubber compounding	**U**	**PSO 1**
CO-4	Explain the formulation of ingredients and describe the mixing procedure for rubber compounding	**U,Ap**	**PSO 1**
CO-5	Describe the process of two roll mixing mills and internal mixers and describe the molding techniques for rubber compounding and explain the theory of sulfur vulcanization and mastication.	**U, Ap**	**PSO 5**
CO-6	Preparation of Latex And Rubber Products by its compounding Techniques	**Ap**	**PSO-7**

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

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	**Course Outcomes**	**PO/ PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understanding the principles of latex compounding methods and how the compounding ingredients are added to form desired products.	**6/1**	**U**	**P**	**L**	
CO-2	Gain an understanding of natural rubber latex processing techniques, including ball milling, dipping process to form the desired product.	**4/1**	**R, U**	**P,C**	**L**	
CO-3	To understand the principles of rubber compounding and describe the additives for rubber compounding and explain the functions of additives used for rubber compounding	**5/1**	**U**	**P**	**L**	

CO-4	Explain the formulation of ingredients and describe the mixing procedure for rubber compounding	**3/1**	**U,Ap**	**P,C**	**L**	
CO-5	Describe the process of two roll mixing mills and internal mixers and describe the molding techniques for rubber compounding and explain the theory of sulfur vulcanization and mastication.	**6/5**	**U, Ap**	**P,C**	**L**	
CO-6	Preparation of Latex and Rubber Products by its Compounding Techniques	**3,1/7**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs :

	PSO-1	PSO- 5	PSO-7	PO-1	PO 3	PO 4	PO 5	PO 6
CO 1	2	-						2
CO 2	3					3		
CO 3	2	-					2	
CO 4	3	-			2			
CO 5	-	2						3
CO 6	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		✓		✓
CO-6	✓			✓

<table>
<tr><td>Discipline</td><td colspan="5">POLYMER CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK4DSEPOC202</td></tr>
<tr><td>Course Title</td><td colspan="5">Polymer Processing Technology</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">4</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 hours</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic knowledge in moulding and its commercial importance</td></tr>
<tr><td>Course Summary</td><td colspan="5">To learn about the various processing techniques and their components. To learn the fundamentals of extrusion and different extrusion processes of thermoplastics. it includes practical experiments in LATEX analysis and providing students with hands-on experience in the laboratory.</td></tr>
</table>

Detailed Syllabus:

<table>
<tr><th>Module</th><th>Unit</th><th>Content</th><th>Hrs</th></tr>
<tr><td rowspan="5">I</td><td colspan="2">Extrusion</td><td>9</td></tr>
<tr><td>1</td><td>Introduction to extrusion, Extrusion process, Extrusion die</td><td>1</td></tr>
<tr><td>2</td><td>Classification of extrusion dies: film and sheet extrusion</td><td>3</td></tr>
<tr><td>3</td><td>Multi-layer extrusion, Spider die, Pipe and Tube die, offset die, etc</td><td>3</td></tr>
<tr><td>4</td><td>Die swell and die defects</td><td>2</td></tr>
<tr><td rowspan="5">II</td><td colspan="2">Injection & Blow Molding</td><td>9</td></tr>
<tr><td>5</td><td>Theory and Principle, Material used, Injection molding cycle, Injection molding machine</td><td>2</td></tr>
<tr><td>6</td><td>Some aspects ofproduct quality, reaction injection moulding (RIM), Blow molding, Extrusion blow molding</td><td>3</td></tr>
<tr><td>7</td><td>Injection blow molding, Stretch blow molding, Blow moulding of PET</td><td>2</td></tr>
<tr><td>8</td><td>Trouble shooting operations</td><td>2</td></tr>
<tr><td rowspan="5">III</td><td colspan="2">Thermoforming</td><td>9</td></tr>
<tr><td>9</td><td>Thermoforming process –introduction</td><td>1</td></tr>
<tr><td>10</td><td>Principles, materials used in Thermoforming process</td><td>2</td></tr>
<tr><td>11</td><td>Types of Thermoforming process</td><td>3</td></tr>
<tr><td>12</td><td>Applications of Thermoforming process</td><td>3</td></tr>
<tr><td rowspan="5">IV</td><td colspan="2">Compression & Transfer Molding</td><td>9</td></tr>
<tr><td>13</td><td>Compression moulding process-introduction</td><td>1</td></tr>
<tr><td>14</td><td>Transfer moulding process: introduction, material used</td><td>2</td></tr>
<tr><td>15</td><td>Types of compression and transfer moulding</td><td>3</td></tr>
<tr><td>16</td><td>Applications of compression and transfer moulding</td><td>3</td></tr>
<tr><td>V</td><td colspan="2">Miscellaneous Processing Methods</td><td>9</td></tr>
</table>

	17	Casting and rotational moulding processes: principles, material used	2
	18	Types and applications	2
	19	Casting, rotational moulding machining and joining processes: principles, material used.	3
	20	Types and applications	2

Polymer Processing Technology Practical 30 Hrs

Module	Unit	Content	Hrs
I	1	• Production of finger caps by dipping process • Production of balloon by dipping process • Production of household gloves by multi dipping process • Practice the production of table mat • Practice the production of rubber chappals • Practice the production of rubber bushes	**30**

Reference

1. A. B. Strong, Plastics: Materials & Processing, Prentice Hall, 2005.
2. D. V.Rosato, Rosato D.V.,Injection Moulding Handbook, CBS Publisher, 2000.
3. D. H. Morton-Jones, Polymer Processing, Chapman & Hall, 2007.
4. A. L. Griff, Plastics Extrusion Technology, Creative Media Partners, LLC, 2021.
5. C. G. Gogos, Z.Tadmor, Principles of polymer processing. John Wiley & Sons, 2013.
6. C. I. Chung, H. Verlag, Extrusion of Polymers: Theory and Practice, 2000.
7. C. A. Harper, E. M. Petrie, Plastic materials and processes: a concise encyclopedia, 2003.
8. Training Manual RTI RRII Kottayam
9. SITTTR lab manual

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Student understand on Extrusion moulding process-its significance, classification, methods and the extrusion die & die defects	**U, R**	**5**
CO-2	Student learn on Principles of injection molding and blow molding, extrusion blow molding, injection blow molding, stretch blow molding, and blow moulding of PET, trouble shooting operations	**R, U**	**1**
CO-3	Students Understand on Thermoforming process	**R, U**	**1**

CO-4	Students Understand on compression & transfer moulding and Casting and rotational moulding processes and its applications.	**U**	**1**
CO-5	Students Understand on Casting and rotational moulding processes- principles, material used, types and applications	**Ap**	**5**
CO-6	Preparation of Latex and rubber products by its compounding techniques	**Ap**	**4**

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

Name of the Course: Credits: 3:0:1 (Lecture : Tutorial : Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Student understand on Extrusion moulding process-its significance, classification, methods and the extrusion die & die defects	**4/5**	**U**	**F, C**	**L**	
CO-2	Student learn on Principles of injection molding and blow molding, extrusion blow molding, injection blow molding, stretch blow molding, and blow moulding of PET, trouble shooting operations	**3/1**	**R, U**	**F**	**L**	
CO-3	Students Understand on Thermoforming process	**7/1**	**R, U**	**C**	**L**	
CO-4	Students Understand on compression & transfer moulding and Casting and rotational moulding processes and its applications.	**3/1**	**R, U**	**C**	**L**	
CO-5	Students Understand on Casting and rotational moulding processes- principles, material used, types and applications	**5/5**	**R, U**	**F, C**	**L**	

CO-6	Preparation of Latex and rubber products by its compounding techniques	**3, 1/4**	**Ap**			**P**

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

Mapping of COs with PSOs and POs

	PSO-1	PSO-4	PSO-5	PO-1	PO-3	PO-4	PO-5	PO-7
CO 1	-	-	2	-	-	2	-	-
CO 2	3		-	-	2	-	-	-
CO 3	2	-		-	-	-	-	3
CO 4	1	-		-	2	-	-	-
CO 5		-	3	-	-	-	2	-
CO 6		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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4DSEPOC203**				
Course Title	Analytical Techniques				
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. 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, and the interpretation of analytical data.				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Analytical Chemistry**	**9**
	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
	2	Qualitative and Quantitative Analysis, Sampling	2
	3	The analytical process: Steps in the analytical process	2
	4	Validation of a method, Use of literature, Analyze Versus Determine	2
II		**Basic Tools of Analytical Chemistry I**	**9**
	5	The Laboratory Notebook, Laboratory Basic Equipments & Measurements: Volumetric Glassware (Volumetric flasks, Pipets, Syringe pipets, Burets & Useof volumetric Glassware,) The Analytical Balance	2
	6	Units for Expressing Concentration**:** Molarity and Formality, Normality, Molality, Weight, Volume, and Weight-to-Volume Ratios, Converting Between Concentration Units, p-Functions	3
	7	Stoichiometric calculations, Selection of glassware, Preparation of standard acid & base solutions	2
	8	Other apparatus: Blood samplers, Desiccators, furnaces & ovens, hoods, wash bottles, Centrifuges & filters,	2
III		**Language of Analytical Chemistry**	**9**
	9	Analysis, Determination, and Measurement, Techniques, Methods, Procedures, and Protocols, Classifying Analytical Techniques, Use of Literature	2

	10	Selecting an Analytical Method: Accuracy, Precision, Sensitivity, Selectivity, Robustness and Ruggedness, Scale of Operation, Equipment, Time, and Cost, Making the Final Choice	3
	11	Developing the Procedure & Standardizing Analytical Methods: Compensating for Interferences, Calibration and Standardization, Sampling, Validation, Analytical signals, Calibrating the signals, and Sensitivity determination.	3
	12	Protocols, The Importance of Analytical Methodology	1
IV		**Errors & their minimization in Chemical Analyses**	**9**
	13	Limitations of analytical methods, Accuracy & Precision, Classification of errors: Determinate & Indeterminate Errors, Minimisation of errors	4
	14	Significant figures, Absolute and relative uncertainty, Propagation of uncertainty	2
	15	Rules of Computing. Problems, Ways of expressing accuracy	3
V		**Statistical Data Treatment and Evaluation**	9
	16	Statistical Analysis of Data: Standard Deviation—The Most Important Statistics, The Confidence Limit, Tests of Significance, Rejection of a Result: The *Q* Test, Statistics for Small Data Sets, Linear Least Squares, Correlation Coefficient and Coefficient of Determination, Detection Limits	5
	17	Statistics of Sampling, The Distribution of Measurements and Results: Populations and Samples: Probability Distributions for Populations, Confidence Intervals for Populations, Probability Distributions for Samples, Confidence Intervals for Samples	4

Analytical techniques Practical 30 Hrs

Module	Unit	Content	Hrs
I	1	**a) Inorganic Volumetric analysis (one burette titration)** **Permanganometry** Estimation of Ferrous iron Estimation of Oxalic acid	7
	2	**Dichrometry** Determination of Ferrous iron using internal & external indicator Determination of Ferric iron after reduction with SnCl2.	8
	3	**Iodimetry & Iodometry** Standardization of thiosulphate using KIO_3 Standardisation of iodine using thiosulphate Determination of copper in copper sulphate	9
	4	**Complexometry** Determination of Zinc, using EDTA Determination of Magnesium	6

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, 7^{th} 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.

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 Gain knowledge about analytical problems and their solutions.	**U**	**1**
CO-2	Learn units for expressing concentration, perform conversions between concentration units, and stoichiometric calculations and prepare standard acid and base solutions.	**A, R**	**1**
CO-3	Learn to select analytical methods, develop procedures and standardize analytical methods.	**U, An**	**5**
CO-4	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, A**	**2**
CO-5	Analyze statistical data & apply statistical methods for small data sets and detection limits, Understand the concepts of rejection of a result	**A, U**	**7**
CO-6	Students understands the various volumetric and gravimetris analysys in laborotory	**Ap**	**4**

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

Name of the Course: Analytical Techniques Credits: 3:0:1 (Lecture : Tutorial : Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
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 Gain knowledge about analytical problems and their solutions.	**1/1**	**U**	**C**	**L**	
CO-2	Learn units for expressing concentration, perform conversions between concentration units, and stoichiometric calculations and prepare standard acid and base solutions.	**1/1**	**An, R**	**C**	**L**	
CO-3	Learn to select analytical methods, develop procedures and standardize analytical methods.	**1/5**	**U, An**	**P,C**	**L**	
CO-4	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.	**2/2**	**U, An**	**P,C**	**L**	
CO-5	Analyze statistical data & apply statistical methods for small data sets and detection limits, Understand the concepts of rejection of a result	**2/7**	**An, U**	**P,C**	**L**	

CO-6	Students understands the various volumetric and gravimetris analysys in laborotory	**3,1/4**	**Ap**	**P**		P

Mapping of COs with PSOs and POs :

	PSO-1	PSO- 2	PSO-4	PSO-5	PSO-7	PO-1	PO 2	PO 3
CO 1	2	-				2		
CO 2	3					2		
CO 3		-		3		2		
CO 4		2					2	
CO 5	-	-			2		2	
CO 6	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4VACPOC201**				
Course Title	Polymers in Daily life				
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	Basic knowledge in Polymer Chemistry				
Course Summary	1. Course deals with the study of different types of polymers and their applications. 2. Give a general understanding about polymer waste management 3. Introduce the concept of sustainability in polymer science				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Polymers**	**9**
	1	Introduction to Polymers- Monomer, Polymer, Polymerization	2
	2	Classification of Polymers- Origin, Structure, Properties. Nomenclature of Polymers	3
	3	Molecular Forces and Chemical Bonding in Polymer	2
	4	Uses of Polymers	2
II		**Commercial Polymers**	**9**
	5	Manufacture, Properties and Applications of Industrial Important Polymers- Polyethylene, Polypropylene, Polystyrene,	2
	6	Polymethylmethacrylate, Polyvinylchloride, Polybutadiene and Polyacetals, PET, Nylon-6,6.	3
	7	Definition, Structure, Applications- Carbon Fibers- Carbon Fiber Reinforced Polymers (CFRP)- Carbon Fiber Reinforced Concrete (CFRC).	3
	8	Advantages of CFRP and CFRC	1
III		**Functional Polymeric Materials**	**9**
	9	Biodegradable Polymers-Definition, Properties, Types, Applications of Biodegradable Polymers in Packaging, Agriculture, and Biomedical Fields.	3
	10	Conducting Polymers –Synthesis & applications of Polyaniline, polypyrrole and polyacetylene	3
	11	Shape Memory Polymers- pH-sensitive polymers, Temperature-responsive polymers, Self-healing polymers.	3
IV		**Polymer Waste Management**	**9**
	13	Introduction to Polymer Waste Management. Plastic Wastes and Litter- Definition, Uses, Global Policies and Regulations.	3
	14	Source, Production and Challenges of Plastic Waste in India. 4 R’s Approach (Reduce, Reuse, Recycle, Recover)	1

	15	Recycling Classification (Mechanical, Chemical and Thermal Processes)- Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides.	2
	16	Biodegradation of Polymer Waste, Polymer Recycling and Recovery, Sortation, Polymer Reprocessing. Polymer Incineration.	3
V	**Polymers for Sustainable Environment**		**9**
	17	Introduction to the Concept of Sustainability in Polymer Science - Environmental Challenges Associated with Conventional Polymers	3
	18	Sustainable Approaches to Polymer Synthesis: Green Chemistry Principles, Renewable Feedstocks. Introduction to Bio-Based Polymers and Their Role in Reducing Carbon Footprint	3
	19	Carbon Credits: Carbon Footprint Calculations.	1
	20	Examination of economic, technical, and regulatory challenges facing the sustainable polymer industry.	2

References

1. J. R. Fried. Polymer Science and Technology, 3rd Edition, Pearson Education, Inc., 2003.
2. M. P. Stevens. Polymer Chemistry: An Introduction, 3rd Edition, Oxford University Press, 1999.
3. R. B. Seymour, C. E. Carraher Jr. Polymer Chemistry: An Introduction, 6th Edition, Marcel Dekker, 2003.
4. G. Odian, Principles of Polymerization, 4th Edition, John Wiley & Sons Inc., 2004.
5. A. Rudin and P. Choi, The Elements of Polymer Science and Engineering. 3rd Edition, Academic Press, 2012.
6. R. F. Gibson. Principles of Composite Material Mechanics, 4th Edition, CRC Press, 2016.
7. S.-J. Park, Carbon Fibers, 2nd Edition, Springer, 2018.
8. M. Inagaki and F. Kang, Carbon Fibers: Structure and Properties, 2nd Edition, Elsevier, 2014
9. A. K. Mohanty, M.Misra, and L. T. Drzal, Natural Fibers, Biopolymers, and Biocomposites, 1st Edition, CRC Press, 2005.
10. R. K. Gupta, Conducting Polymers: Chemistries, Properties and Biomedical Applications, 1st Edition, CRC Press, 2022.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamental concepts of polymers. Discuss the manufacture, properties and uses of different polymers	**U, R**	**1,2**

CO-2	Discuss emerging polymer materials along with their properties and applications	**U**	**1,2**
CO-3	Evaluate the challenges associated with polymer waste management and analyze global policies and regulations.	**E,An**	**3**
CO-4	Apply the 4 R's approach to address the challenges of plastic waste in India	**Ap**	**8**
CO-5	Assess the environmental challenges and evaluate sustainable approaches to polymer synthesis. Evaluate the economic, technical, and regulatory challenges facing the sustainable polymer industry.	**U, An, E**	**7, 8**

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

Name of the Course: Polymers in Daily life Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/ PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Understand the fundamental concepts of polymers. Discuss the manufacture, properties and uses of different polymers	**1/1,2**	**U, R**	**C,**	**L**	
2	Discuss emerging polymer materials along with their properties and applications	**1/1,2**	**U**	**C**	**L**	
3	Evaluate the challenges associated with polymer waste management and analyze global policies and regulations.	**1,2/3**	**E,An**	**C**	**L**	
4	Apply the 4 R's approach to address the challenges of plastic waste in India	**1,6/8**	**Ap**	**C**	**L**	
5	Assess the environmental challenges and evaluate sustainable approaches to polymer synthesis. Evaluate the economic, technical, and regulatory challenges facing the sustainable polymer industry.	**6,7,8 /7,8**	**U, An, E**	**C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO1	2	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-
CO2	2	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	-	-	2	2	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	3	2	-	-	-	-	2	-	-
CO5	-	-	-	-	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4VACPOC202**				
Course Title	Rubber Technology and Product Manufacturing				
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	-	0 hours	3
Pre-requisites	A basic idea of polymers and polymer chemistry				
Course Summary	This course provides an understanding of natural and synthetic rubbers, latex processing, compounding and vulcanization of latex, rubber processing, compounding and vulcanization of rubber, characterisation of finished products, quality control and quality maintenance of rubber products.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to rubbers-Natural and synthetic**	**9**
	1	History of Rubber	1
	2	Natural,synthetic rubber - SBR, polybutadiene rubber, ethylene propelene diene rubber, butyl rubber, ntrile rubber, neoprene, silicone, fluorocarbon rubber - synthesis only	4
	3	Properties of rubber - glass transition temperature and mechanical properties (Tensile strength, percenrage of elongation, compression set, fatigue resistance, resilience, hysteresis, hardness)	4
II		**Latex processing, compounding and vulcanization**	**9**
	5	Latex compounding. Latex additives - fillers, accelerators, plasticizers, antioxidants.	2
	6	Compounding ingredients - inorganic and organic materials. Manufacturing techniques- mixing, extrusion, calendering, moulding.	3
	7	Vulcanization, vulcanizing agents (sulfur, peroxides, accelerators), Factors affecting vulcanization	2
	8	Dipping process for latex products, foam latex processing, coagulation methods.	2
III		**Rubber processing, compounding and vulcanization**	**9**
	9	Rubber Compounding. Rubber additives and fillers - carbon black, plasticizers, accelarators	3
	10	manufacturing techniques - mixing and mastication, internal mixer, two roll mill. Moulding techniques - extrusion, calendering, moulding	3
	11	Vulcanization process - Importance, methods and agents	2
	12	Retardents	1
IV		**Characertisation of finished products**	**9**

	13	Physical characterisation (surface finish, dimensional accuracy)	2
	14	Mechanical characterisation (Strength, flexibility, durability)	2
	15	Chemical characetrisation (composition, reactions)	2
	16	Electrical characterisation (conductivity, resistance)	2
	17	Thermal characterisation (heat resistance, thermal conductivity)	1
V		**Quality control and product quality maintenance of rubber products**	**9**
	18	Establishing quality standards	3
	19	Quality assurance during prototyping and production,quality management systems (eg.six sigma)	3
	20	Defect detection and prevention, storage and handling of raw materials	3

References

1. J. M. Martin, W. K. Smith, Handbook of Rubber technology, CBS Publisher, 2007
2. J. E. Mark, B. Erman, F. R. Eirich, The science and technology of rubber, Elsevier Press, 2005
3. S. Blow, Handbook of Rubber Technology, Hanser Gardner, 2000.
4. C. W. Evans, Practical Rubber Compounding and processing, Applied science Publishers, London,1981.
5. B. Rodgers, Rubber compounding: Chemistry and applications, CRC press,1st edn, 2016.
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7. S. Ebnesajjad, Rubber Testing:Characterisation and Applications,William Andrew Publisher, 2001.
8. R. N. Datta, Rubber Analysis:Polymers,compounds and products, Smithers Rapra Technology publishers, 2001.
9. P. Ghosh, polymer science & technology, 3rd edition, Tata McGraw Hill Education Pvt. Ltd, New Delhi, 2011.
10. M. Morton, Rubber Technology, Van Nostrand Reinhold, New York, 2002.
11. W. Hoffman, Rubber Technology Handbook, Hanser Publishers, Munich 1996.
12. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, Polymer Science, 4th Edn., New Age International Publishers, 2021.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of rubber materials	**U**	**1**
CO-2	Knowledge of latex processing techniques	**Ap**	**5**
CO-3	Knowledge of rubber processing techniques	**Ap**	**5**
CO-4	Characterisation of rubber compounds and products	**E.An**	**1,5**
CO-5	Quality control and assurance	**Ap**	**5**

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

Name of the Course: Rubber Technology and Product Manufacturing

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

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understanding of rubber materials	1/1	U	C	L	
2	Knowledge of latex processing techniques	1/5	Ap	C, P	L	
3	Knowledge of rubber processing techniques	1/5	Ap	C, P	L	
4	Characterisation of rubber compounds and products	1/1,5	E,An	P	L	
5	Quality control and assurance	2,8/5	Ap	C	L	

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

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	-	-	-	-	-	2						2	-	-	-
CO2	-	-	-	-	3	-	2						-	-	-	-
CO3	-	-	-	-	3	-	2						-	-	-	-
CO4	2	-	-	-	3	-	3						2	-	-	-
CO5	-	-	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4SECPOC201**				
Course Title	Basic Skills for Polymer 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	Basic knowledge in chemistry				
Course Summary	1. Helps students to understand laboratory safety protocols, emergency procedures etc fostering a safe working environment. 2. Gain basic information about polymers. 3. By examining the relationship between polymer structure and properties, students will develop the ability to predict and manipulate material behaviors.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Lab Safety Protocols, Rules and Green Practices**	**9**
	1	Introduction to lab safety- Knowledge of hazard information and symbols	2
	2	Precautionary labels, Material Safety Data Sheets, GHS symbols and their definitions, NFPA classification system.	2
	3	Storing, handling and disposing of Chemicals- using personal protective equipment, handling lab equipment's. Emergency procedures in chemical splashes to skin and eyes, burns and electric shock.	3
	4	Green Chemistry: Emergence of Green Chemistry, Need for Green Chemistry, Goals of Green Chemistry. Limitations.	2
II		**Basics of Polymers**	**9**
	5	General idea of monomers, polymers and polymerization. Classification of polymers-Natural and synthetic, Organic and Inorganic-	1
	6	Thermoplastic, thermosets and elastomers, crystalline and amorphous, Homopolymers and copolymers.	2

	7	Addition polymers- mechanism of addition polymerization (Cationic, anionic and free radical)	3
	8	Condensation polymers- mechanism of condensation polymerization.	2
III		**Structure property Relationship and use of Polymers**	**9**
	9	Structure of polymers, amorphous, semicrystalline and crystalline states in polymers	2
	10	Glass transition, melting and crystallization temperature of polymers	3
	11	Effect of structure on the chemical, mechanical, electrical and optical properties of polymers.	3
	12	Uses of Polymers	1
IV		**Practical Skill Development**	**9**
	13	Demonstration of fire extinguisher	1
	14	Reading a MSDS data sheet.	3
	15	Reading a NFPA Safety diamond.	3
	16	Laboratory accidents- case study report.	2
V	17	Explore real-world applications and problem-solving strategies through a visit to an analytical laboratory, focusing on resolving industrial challenges.	9

References:

1. F. W. Billmeyer. Text Book of Polymer Science, 3rd Edition, Wiley-Interscience, 1984.
2. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar. Polymer Science, 1st Edition, New Age International, 1986.
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5. A. S. Matlack, Introduction to Green Chemistry, Marcel Dekker, 2001.
6. M. Morton, Rubber Technology, 3rd Edition,Chapman and Hall, 1999.
7. J. A. Brydson, Rubber Chemistry, 1st Edition, Springer, 1978.
8. B. Kothandaraman, Rubber Materials, ANE Books, 2008.
9. I. Franta, Elastomers and Rubber Compounding Materials, 1st Edition, Elsevier, 1989.
10. Jerzy Urbanski. Handbook for Analysis of Synthetic Polymers and Plastics, Ellis Horwood, Ltd. 1977.

Course Outcomes

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

CO-1	Understanding of lab safety fundamentals and the ability to interpret precautionary labels. Acquire skills in handling laboratory equipment and chemicals.	**U, An, Ap**	**PSO-3, 4**
CO-2	Develop a thorough comprehension of polymer basics and enable them to distinguish between natural/synthetic, organic/inorganic, and various polymer types.	**U, R, Ap**	**PSO-1**
CO-3	Understand the mechanisms behind addition and condensation polymerization, allowing for analysis and synthesis of polymers with precision.	**U, Ap, C**	**PSO-2**
CO-4	Enhance their knowledge of polymer structure-property relationships,and how these properties influence chemical, mechanical, electrical, and optical characteristics.	**R, Ap, An**	**PSO-5**
CO-5	Gain practical exposure to real-world industrial applications and problem-solving strategies through a visit to an analytical laboratory, fostering collaboration and innovation in resolving industrial challenges.	**U, Ap, An, C**	**PSO-6**

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

Name of the Course: Basic Skills in Polymer Industry, Credits: 3:0:1 (Lecture : Tutorial : Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Understanding of lab safety fundamentals and the ability to interpret precautionary labels. Acquire skills in handling laboratory equipment and chemicals.	**6/3, 4**	**U, An Ap**	**C, P**	**L**	
2	Develop a thorough Comprehension of polymer basics and enable them to distinguish between natural/synthetic, organic/inorganic, and various polymer types.	**1/1**	**R, U, Ap**	**C**	**L**	

3	Understand the mechanisms behind addition and condensation polymerization, allowing for analysis and synthesis of polymers with precision.	**1/2**	**U, Ap, Ac**	**C**	**L**	
4	Enhance their knowledge of polymer structure-property relationships, and how these properties influence chemical, mechanical, electrical, and optical characteristics.	**1,6/5**	**R, Ap, An**	**C**	**L**	
5	Gain practical exposure to real-world industrial applications and problem-solving strategies through a visit to an analytical laboratory, fostering collaboration and innovation in resolving industrial challenges.	6,8/6	U, Ap, An, C	C		P

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

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PO 1**	**PO 2**	**PO 3**	**P O 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO1	-	-	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO2	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
CO3	-	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-
CO4	-	-	-	-	2	-	-	-	2	-	-	-	-	2	-	-
CO5	-	-	-	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK4SECPOC202**				
Course Title	Analytical methods in Polymer Science				
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	Basic knowledge of Polymer chemistry				
Course Summary	1. Detailed study about different types of polymers, their properties and application. 2. The course deals with the production and modification of natural rubber 3. The course offers practical experience in latex analysis and real-world application exploration in an analytical laboratory setting.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Polymeric Materials**	**09**
	1	Introduction to Polymers- Comparison with Conventional Materials, Classification, Properties, Applications.	02
	2	Thermoplastics: Vinyl polymers - Styrene and its copolymers, Acrylics, Polyamides, Polyesters,	03
	3	Cellulose and its Derivatives	02
	4	Polycarbonates, Polyacetals, PVA.	02
II		**Thermosets**	**09**
	5	PF, MF, UF, Epoxy resins, Unsaturated polyester, Vinyl esters	02
	6	Natural Rubber, Isoprene Rubber, Butyl Rubber,	03
	7	Nitrile Rubber, Chloroprene Rubber, SBR.	02
	8	Vulcanization, Rubber chemicals.	02
III		**Natural Rubber from Latex**	**09**
	9	Different Processes in Collection, Concentration and Stabilization of Latex	02
	10	Latex Compounding: Vulcanizing Agents, Latex Compounding Acids, Wetting, Dispersing and Emulsifying Agents,	03
	11	Stabilizers, Thickening Agents, Fillers & Other Additives- Their Functions and Comparison.	03

	12	Comparative characterization of natural and synthetic polymers- TGA, FTIR, XRD etc.	01
IV		**Latex Analysis**	**09**
	13	Latex analysis (a) Total Solid Content (b) Dry rubber content (c) Total alkalinity	09
V	14	Explore real-world applications and problem-solving strategies through a visit to an analytical laboratory, focusing on resolving industrial challenges.	09

References:

1. R. J. Young, P. A. Lovell, Introduction to Polymers, CRC Press, 3rd Edition, 2013.
2. C. E. Carraher, Jr. Polymer Chemistry: An Introduction, Marcel Dekker, 6th Edition, 2003.
3. J. S. Dick and R. A. Annicelli, Rubber Technology Handbook, Hanser Publishers, 2001.
4. J.-P. Pascault, H. Sautereau, J. Verdu, R. J. J. Williams. Thermosetting Polymers, CRC Press, 2002.
5. S. H. Goodman, R. A. Malloy, Handbook of Thermoset Plastics, Elsevier Science, 1998.
6. M. R. Sethuraj and Ninan T Mathew. Natural Rubber: Biology, Cultivation, and Technology, Elsevier Science, 2012.
7. J. E. Mark, Polymer Data Handbook, Oxford University Press, 1999.
8. J. D. Menczel and R. B. Prime. Thermal Analysis of Polymers: Fundamentals and Applications, John Wiley & Sons, 2009.
9. G. Odian, Principles of Polymerization, 4th Edition, John Wiley & Sons, 2004.
10. J. Brandrup, E. H. Immergut, E. A. Grulke, Polymer Handbook, 4th Edition, Wiley-Interscience,1999.
11. L. H. Sperling, Introduction to Physical Polymer Science, 4th Edition, John Wiley & Sons, 2006.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamental concepts of polymeric materials and their significance in various industries. Analyze the structure-property relationships of differenttypes of polymers to predict their behavior in various environments and applications.	**U, R**	**1,5**
CO-2	Discuss the principles of vulcanization and the role of rubber chemicals in modifying the properties of rubber materials.	**U, R**	**4**
CO-3	Apply acquired knowledge to solve practical problems related to the processing, formulation, and performance	**U, R**	**1,3**

	evaluation of thermosetting polymers and rubber materials.		
CO-4	Analyze the comparative characterization techniques for natural and synthetic polymers, and interpret the results obtained from these techniques to understand the structural and thermal properties of polymers.	**U, R, Ap**	**2,6**
CO-5	Gain practical exposure to real-world industrial applications and problem-solving strategies through a visit to an analytical laboratory, fostering collaboration and innovation in resolving industrial challenges.	**U, An, C**	**6,7**

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

Name of the Course: Polymer Analysis Credits: 3:0:0 (Lecture : Tutorial : Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Understand the fundamental concepts of polymeric materials and their significance in various industries. Analyze the structure-property relationships of different types of polymers to predict their behavior in various environments and applications.	**1/1, 5**	**U, R**	***C***	***L***	
2	Discuss the principles of vulcanization and the role of rubber chemicals in modifying the properties of rubber materials.	**1/4**	**U, R**	**C**	**L**	
3	Apply acquired knowledge to solve practical problems related to the processing, formulation, and performance evaluation of thermosetting polymers and rubber materials.	**1, 2/1, 3**	**U, R**	**C**	**L**	
4	Analyze the comparative characterization techniquesfor natural and synthetic polymers, and interpret the results obtained from these techniques to understand the structural and thermal properties of polymers.	**1/2, 6**	**U, R, Ap**	**C**	**L**	

5	Gain practical exposureto real-world industrial applications and problem-solving strategies through a visit to an analytical laboratory, fostering collaboration and innovationin resolving industrial challenges.	**3, 6, 8/6, 7**	**U, An, C**	**C, P**		**P**

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

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PO 1**	**PO 2**	**PO 3**	**P O 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO1	2	-	-	-	2	-	-	-	3	-	-	-	-	-	-	-
CO2	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	-
CO3	2	-	2	-	-	-	-	-	2	2	-	-	-	-	-	-
CO4	-	2	-	-	-	2	-	-	2	-	-	-	-	-	-	-
CO5	-	-	-	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSCPOC301**				
Course Title	Polymer 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	An understanding of general chemistry concepts and basic understanding of matter.				
Course Summary	This course provides a comprehensive understanding of polymer chemistry. Students will learn about different types of polymerization techniques and polymer analysis.				

Detailed Syllabus:

Module	Unit	Content	Hrs	CO No.
I		**Free Radical addition Polymerization**	**9**	
	1	Chain growth polymerization. Mechanism of chain growth polymerization – initiation, propagation and termination.	2	1
	2	Types of free radical initiators (per oxo, azo and redox initiators)	2	1
	3	Initiator efficiency, inhibitors and retarders – functions and examples. Chain transfer reactions.	3	1
	4	Kinetics of chain growth polymerization, kinetic chain length, thermal and electrical polymerization.	2	1
II		**Ionic and stereo regular Polymerization**	**9**	
	5	Ionic polymerization – anionic and cationic catalysis, solvent effects in ionic polymerizations.	2	2
	6	Mechanism and kinetics of anionic and cationic polymerizations, counter ions.	3	2
	7	Living polymers, coordination polymerization, and stereo regularity.	2	2
	8	Ziegler Natta catalysts, Bimetallic & mono metallic mechanisms.	2	2
III		**Condensation Polymerisation**	**9**	
	9	Copolymerization, random, alternate, block and graft.	2	3
	10	Copolymerization involving two monomers (Free radical mechanism).	2	3
	11	Reactivity ratio, its determination Q-e scheme, polymerization techniques (Bulk, solution, suspension and emulsion).	3	3
	12	Melt, solution an interfacial condensation.	2	3
IV		**Step growth Polymerization**	**9**	
	13	Step growth polymerization, average functionality, basic characteristics.	2	4
	14	Mechanism of self –catalyzed and non-catalyzed esterification.	3	4
	15	Ring opening and interfacial polymerization.	2	4
	16	Carothers equation and extent of reaction.	2	4

V	**Molecular Mass and Size of Polymers**		**9**	
	17	Absolute and relative methods of molecular mass determination.	2	5
	18	Determination of Number, average molecular mass, End group analysis.	3	5
	19	Weight average molecular mass-ultracentrifugation (principle only).	2	5
	20	Viscosity average molecular mass, Gel permeation chromatography.	2	5

Polymer Chemistry Practical– 30 Hours

Detailed Syllabus:

Content	**Hrs**
Module I: Identification of Plastic and Rubbers (10 samples).	**15**
Module II: Preparation of Polymer – PMMA, Nylon 6, Polystyrene by mass polymerization.	**15**

References

1. Malcon P. Steves, Polymer chemistry-An introduction, 3rd edition, Oxford University Press, 1999.
2. F. W. Billmayer, Text book of Polymer Science, 3rd edition, John Wiley & Sons, 1984.
3. V. R. Gowariker, N. V. Viswanathan &J. Sreedhar, Polymer Science, New Age International Publishers, 2005.
4. P. Bahadur & N. V. Sastry, Principles of Polymer Science, Narrora Publishing House, 2nd Edition, 2006.
5. Premamoy Ghosh, Polymer Science & Technology, 3rd edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2011.
6. G. Odian, Principles of polymerization, 3rd edition, John Wiley & Sons, 2004.
7. G. S. Misra, Introductory Polymer Chemistry New Age International Publishers & Distributors, New Delhi, 1993.
8. V. K. Ahluwalia & A. Misra, Polymer Science-A Text Book, Ane Books, India, New Delhi, 2016.
9. S.P. Chattopadhyay, Principles of Polymer Engineering, PHI Learning Pvt. Ltd., 2012.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding chain growth polymerization mechanisms, initiator types, and kinetics prepares learners to design polymerization reactions, control polymer properties, and apply diverse initiators and inhibitors for tailored polymer synthesis.	**An**	**1**
CO-2	Understanding ionic polymerization mechanisms, catalyst effects, and stereochemistry prepares students to design precise polymers, control living polymerization for tailored properties, and utilize	**U**	**6**

	advanced catalysts like Ziegler-Natta for industrial applications.		
CO-3	Studying copolymerization elucidates random, alternate, block, and graft structures via free radical mechanisms, reactivity ratio determination, and various polymerization techniques (bulk, solution, suspension, emulsion, melt, solution, interfacial condensation) for designing diverse polymer architectures tailored to specific applications.	**E,Ap**	**1,6**
CO-4	Exploring step growth polymerization unveils concepts like average functionality and key characteristics, alongside mechanisms of self-catalyzed and non-catalyzed esterification, ring opening, interfacial polymerization, and Carothers equation for understanding reaction extents and polymer properties.	**U**	**1,2**
CO-5	The course equips students to determine molecular masses using absolute and relative methods, analyze end groups for number and average molecular mass, and utilize ultracentrifugation and gel permeation chromatography to determine weight average and viscosity average molecular masses.	**U,C**	**2**
CO-6	The course outcomes include the ability to identify plastics and rubbers, prepare polymers like PMMA, Nylon 6/6, and Polystyrene through mass polymerization techniques.	**Ap**	**1,5**

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

Note: 1 or 2 COs/module

Name of the Course Polymer chemistry: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
CO-1	Understanding chain growth polymerization mechanisms, initiator types, and kinetics prepares learners to design polymerization reactions, control polymer properties, and apply diverse initiators and inhibitors for tailored polymer synthesis.	**1/1**	**An**	**F**	**L**	

CO-2	Understanding ionic polymerization mechanisms, catalyst effects, and stereochemistry prepares students to design precise polymers, control living polymerization for tailored properties, and utilize advanced catalysts like Ziegler-Natta for industrial applications.	**6/6**	**U**	**F**	**L**	
CO-3	Studying copolymerization elucidates random, alternate, block, and graft structures via free radical mechanisms, reactivity ratio determination, and various polymerization techniques (bulk, solution, suspension, emulsion, melt, solution, interfacial condensation) for designing diverse polymer architectures tailored to specific applications.	**6/1,6**	**E,Ap**	**C**	**L**	
CO-4	Exploring step growth polymerization unveils concepts like average functionality and key characteristics, alongside mechanisms of self-catalyzed and non-catalyzed esterification, ring opening, interfacial polymerization, and Carothers equation for understanding reaction extents and polymer properties.	**2/1,2**	**U**	**F**	**L**	
CO-5	The course equips students to determine molecular masses using absolute and relative methods, analyze end groups for number and average molecular mass, and utilize ultracentrifugation and gel permeation chromatography to determine weight average and viscosity average molecular masses.	**2/2**	**U,C**	**M**	**L**	
CO-6	The course outcomes include the ability to identify plastics and					

	rubbers, prepare polymers like PMMA, Nylon 6/6, and Polystyrene through mass polymerization techniques.	**3/1,5**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO6**
CO 1	2	-	-	-	2	-	-	-
CO 2	-	-	-	3	-	-	-	2
CO 3	3	-	-	2	-	-	-	3
CO 4	2	3	-	-	-	2	-	-
CO 5	-	2	-	-	-	3	-	-
CO 6	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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSCPOC302**				
Course Title	Physical 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	Knowledge in state of matter and basic Knowledge in thermodynamics and kinetics.				
Course Summary	This course provides understanding in concepts and theories of Thermodynamics, Chemical kinetics, Equilibrium chemical process and solid state.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Solid state**		**12**
	1	Solid state: characteristics of solids, types of solids: crystalline and amorphous, crystal lattice structure and unit cells, mechanical properties of solids: elasticity, plasticity, hardness.	3
	2	Isotropy and anisotropy, Elements of symmetry of crystal. Crystal systems, Bravais lattices. Laws of crystallography, Miller indices, Representation of lattice planes of cubic crystals. Diffraction of X-rays by crystals: Braggs' equation-derivation and application, identification of type of cubic crystal. Rotating crystal and powder method.	4
	3	Structure of NaCl, KCl and CsCl. Defects in crystals - Schottky and Frenkel defects.	3
	4	Liquid crystals: Types of liquid crystals- smectic, nematic and cholesteric. Molecular arrangements in various states of liquid crystals, uses of liquid crystals.	2
II	**Thermodynamics**		**12**
	5	Zeroth law of thermodynamics. First law of thermodynamics: Definition of Internal energy and Enthalpy. Statement of first law. Heat capacities at constant volume (Cv) and at constant pressure (Cp).Relation between Cp and Cv. Reversible process and maximum workThe Joule-Thomson effect. Derivation of the expression for Joule-Thomson coefficient. Sign and magnitude of JouleThomson coefficient, inversion temperature.	3
	6	Second law of thermodynamics: Need for II law. Different statements of second law- The Carnot cycle and its efficiency. Carnot's theorem and its proof.	3
	7	Concept of entropy: Definition and physical significance. Entropy change for reversible and irreversible processes and in phase changes. Dependence of entropy on T, P and V. Gibb's and Helmholtz free energies and their significances. Criteria of	4

		equilibrium and spontaneity. Gibb's- Helmholtz equation. Dependence of Gibb's free energy change on temperature, volume and pressure. Clausius – Clapeyron equation and its applications.	
	8	Partial molar quantities: Chemical potential. Concept of fugacity.	2
III	**Chemical and Ionic Equilibrium**		**12**
	9	Thermodynamic derivation of law of mass action. Relation between Kp, Kc and Kx. Vant Hoff reaction isotherm. Variation of equilibrium constant (Kp & Kc) with temperature – The Vant Hoff equation.	4
	10	Ionic equilibrium: Ionic product of water. Effect of solvents on ionic strength. Levelling effect. Ionization of weak acids and bases. pKa and pKb values. Solubility product and common ion effect and their applications, pH and its determination by indicator methods. Buffers and calculation of their pH - Henderson's equation.	4
	11	Hydrolysis of salts of all types. Degree of hydrolysis and hydrolysis constant. Relation between hydrolysis constant and ionic product of water.	4
IV	**Chemical Kinetics**		**12**
	12	Order and molecularity of Reaction, Derivation of Integrated Rate Equation of Zero, First, Second and n^{th} Order Reaction and Examples.	2
	13	Determination of order of reactions: - Graphical and analytical methods use integrated rate equations, Fractional life- method, Differential rate equation method, Isolation method.	2
	14	Kinetics of Complex Reactions: Derivation of Rate Equations of (a) Opposing Reactions when both Forward and Backward Reactions are of First Order. (b) First Order Consecutive Reactions. (c) Parallel Reactions Forming two Products with First Order Rate Process. Qualitative Idea of Chain Reactions. Kinetics of chain growth polymerisation reactions, kinetic chain length.	3
	15	Influence of temperature on rate of reaction: Arrhenius equation, Determination of Arrhenius parameter, Energy of activation and its significance.	2
	16	Collision theory, Derivation of the rate equation for a second order reaction based on collision theory, Unimolecular reactions- Lindeman mechanism, Steady state approximation.	3
V		**Phase Equilibria**	**12**
	17	Phase Equilibria -Terminology, the phase rule, thermodynamic derivation of phase rule.	2
	18	Application to (a) water system (b) sulphur system (c) solid-liquid equilibria involving simple eutectic system such as Pb-Ag system, KI-water system, application to solid-liquid equilibria involving simple eutectic system such as Pb-Ag system, Freezing mixtures, thermal analysis and desilverisation of lead.	5
	19	Solid-liquid equilibria involving compound formation with congruent and incongruent melting points:- $FeCl_3$- H_2O system and Na_2SO_4-H_2O system.	3

	20	Solid–gas system- decomposition of $CaCO_3$, dehydration of $CuSO_4.5H_2O$, deliquescence and efflorescence.	2

References:

1. Gurdeep Raj Advanced Physical Chemistry GOEL Publishing House, Meerut, 2004.
2. Puri, Sharma, Pathania, Principles of physical Chemistry Vishal publishing company, 2013.
3. S. Glasstone, Thermodynamics for Chemists, East –West Press Private Ltd., New Delhi, 2008.
4. K. J. Laidler, Chemical kinetics, 3rd Edn. Harper & Row, 1987.
5. C. Kalidas, Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, New Age International, 2005.
6. J. W. Moore, R. G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, 1981.
7. J. Rajaram, J. C. Kuriakose, Kinetics and Mechanisms of Chemical Transformations, Macmillan India, 2000.
8. G. W. Castellan, Physical Chemistry, Addison-Lesley Publishing, 2022.
9. R. A. Albert, R. J. Silby, Physical Chemistry, Wiley Eastern, 2002.
10. E. N. Yeremin, Fundamentals of Chemical Thermodynamics, MIR Publishers 1981.
11. S. Glasstone, Introduction to Electrochemistry, Biblio Bazar, 2011.
12. B. K. Sharma, Electrochemistry, Krishna Prakashan, 1985.
13. F. W. BillmeyerJr., Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.
14. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, 1988.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Differentiate between amorphous and crystalline solids, understand the anisotropy, symmetry, X-Ray diffraction study of crystal structure and identify the imperfections in crystals.	**U, An**	**1, 2**
CO-2	Apply laws of thermodynamics in physics and chemical systems.	**U, Ap**	**1, 2**
CO-3	Understand different laws and principles of physical chemistry.	**U, Ap**	**1, 2**
CO-4	Understand the basic concept of thermodynamics, chemical kinetics, and ionic equilibrium.	**U**	**1, 2**
CO-5	Discussion of phase rule and its applications of various systems.	**U, An**	**1, 2**

CO-6	Enhance their knowledge of polymer structure-property relationships, thermodynamics of polymers. Understand the mechanisms behind addition and condensation polymerization, and kinetics of polymers.	**U, An**	**2, 5**

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

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Differentiate between amorphous and crystalline solids, understand the anisotropy, symmetry, X-Ray diffraction study of crystal structure and identify the imperfections in crystals.	**1/1,2**	**U, An**	**F, C**	**L**	
2	Understand the basic concept of thermodynamics, chemical kinetics, and ionic equilibrium.	**1/1,2**	**U**	**P**	**L**	
3	Enhance their knowledge of polymer structure-property relationships, thermodynamics of polymers	**1/1,2**	**R, An**	**F, P**	**L**	
4	Understand the mechanisms behind addition and condensation polymerization, and kinetics of polymers.	**1/1,2**	**R, U**	**C, M**	**L**	
5	Discussion of phase rule and its applications of various systems.	**1/1,2**	**U, An**	**C, M**	**L**	

6	Enhance their knowledge of polymer structure-property relationships, thermodynamics of polymers. Understand the mechanisms behind addition and condensation polymerization, and kinetics of polymers.	**1/2, 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**	**PSO 6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	1	-	-	-	-	2	-	-	-	-	-
CO 3	2	-	-	-	-	-	2	-	-	-	-	-
CO 4	1	2	-	-	-	-	2	-	-	-	-	-
CO 5	1	2	-	-	-	-	2	-	-	-	-	-
CO 6	-	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	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSCPOC303**				
Course Title	Organic 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	An idea about organic compounds, reaction mechanisms and functional groups.				
Course Summary	This course covers the cycloalkanes and conformations, carboxylic acids and esters, organic compounds containing N and S, heterocyclic compounds and drugs & supramolecular polymers.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Cycloalkanes and Conformations**		**12**
	1	Cycloalkanes: Nomenclature, methods of formation (from halides, Simmons-Smith reaction) and reactions.	3
	2	Baeyer’s strain theory and its limitations, ring strain in cyclopropane and cyclobutane. Theory of strainless rings, banana bonds in cyclopropane. Ring, angular and torsional strain, relative stabilities.	3
	3	Conformations: Conformational analysis of ethane, n-butane, cyclohexane and mono substituted cyclohexanes. Fisher, Newman, saw-horse and wedge projections.	3
	4	Introduction to polycyclic alkanes: decalin, cubane, prismane and adamantane. Large ring compounds: Muscone and civetone	3
II	**Carboxylic acids and Esters**		**12**
	5	Carboxylic acids and their derivatives: - Preparation and properties of aliphatic and aromatic carboxylic acids. Ascent and descent series in aliphatic carboxylic acids.	4
	6	Effect of substituents on acidity of aliphatic and aromatic carboxylic acids. Preparation, properties and uses of anthranilic acid, cinnamic acid, lactic acid, salicylic acid, adipic acid, acid anhydrides, amides, esters, coumarin, malic acid, tartaric acid and citric acid.	4
	7	Esters: Preparation, Physical and Chemical Properties-Saponification, ammonolysis, Bouveault-Blanc reduction, Adkin’s method, HVZ method, Claisen condensation.	4
III	**Organic compounds containing N and S**		**12**
	8	Methods of preparation of aliphatic (reaction of alkyl halide or alcohol with ammonia) and aromatic (reduction, Hoffmann degradation) amines.	3
	9	Methods of separation of amine mixtures - Hoffmann and Hinsberg methods.	2
	10	Hoffman exhaustive methylation	1
	11	Preparation and uses of benzene diazonium salts.	1
	12	Benzidine rearrangement and its mechanism.	1

	13	Preparation, structure and properties of urea.	2
	14	Methods of preparation of mercaptans, sulphoxides, sulphones, sulphonic acid, sulphanilic acid and sulphanilamide.	2
IV	**Heterocyclic compounds and Drugs**		**12**
	15	Heterocyclic compounds: Introduction, classification and nomenclature. Aromaticity in heterocyclic compounds.	3
	16	General methods of preparation and properties of furan, thiophene, pyrrole, indole, pyridine, quinoline and isoquinoline. Importance of heterocyclic compounds in medicine and biochemistry.	5
	17	Drugs-Classification of Drugs on the basis of Application with examples.	2
	18	Sulphonamides, antimalarials and chemotherapy.	2
V	**Supramolecular chemistry**		**12**
	19	Introduction, concept of Molecular recognition, Host-guest interactions, Types of non-covalent interactions- ion-ion interactions, ion-dipole interactions, dipole-dipole interactions, London dispersion interactions, hydrogen bonding interactions, pi-pi stacking, Closed shell interactions.	6
	20	Synthetic molecular receptors (structure and applications) - Tweezers, Cryptands, Carcerands, Cyclophanes, Cyclodextrins and Calixarenes.	3
	21	Molecular recognition in DNA and protein structure. Introduction to Dendrimers, PAMAM and PEGlyated dendrimers, Supramolecular polymers (basic idea)	3

References

1. K. S. Tewari, S. N. Mehrotra, N. K. Vishnoi., A Text Book of Organic Chemistry, Vikas Publishing House (Pvt) Ltd., New Delhi, 1998.
2. I. L. Finar, Organic Chemistry Vol – 1 & 2, 5th Edition, Pearson Education, New Delhi, 2002.
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5. Francis A. Carey, Organic Chemistry. McGraw Hill, Fourth Edition, 2000.
6. S. H. Pine, Organic Chemistry, Prentice Hall, 1987.
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9. Katsuhiko Ariga, Toyoki Kunitake., Supramolecular chemistry-Fundamentals and applications, Springer publications, 2006.

Course Outcomes

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

CO-1	Describe the nomenclature, preparation and theories of cycloalkanes and its conformational analysis	**U**	**1,6**
CO-2	Describe the preparation, properties and applications of carboxylic acids and esters.	**U**	**1**
CO-3	Describe the preparation and Chemistry of Nitrogen and sulphur compounds and distinguish primary, secondary and tertiary amines.	**U**	**1**
CO-4	Outline the chemistry of simple heterocyclic compounds and classify drugs.	**U, Ap**	**1**
CO-5	Explain the concept of molecular recognition, synthetic molecular receptors and its application.	**U, Ap**	**5**

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

Note: 1 or 2 COs/module

Name of the Course Organic 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	Describe the nomenclature, preparation and theories of cycloalkanes and its conformational analysis	**1,2/1,6**	**U**	**C**	**L**	
2	Describe the preparation, properties and applications of carboxylic acids and esters.	**1/1**	**U**	**C**	**L**	
3	Describe the preparation and Chemistry of Nitrogen and sulphur compounds and distinguish primary,	**1/1**	**U**	**C**	**L**	

	secondary and tertiary amines					
4	Outline the chemistry of simple heterocyclic compounds and classify drugs.	**1,2/1**	**U, Ap**	**C**	**L**	
5	Explain the concept of molecular recognition,synthetic molecular receptors and its application.	**1/5**	**U, Ap**	**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	PSO5	PSO 6	PO1	PO2	PO3	PO4	PO5
CO 1	3	-	-	-	-	1	3	2	-	-	-
CO 2	3	-	-	-	-	-	3	-	-	-	-
CO 3	3	-	-	-	-	-	3	-	-	-	-
CO 4	2	-	-	-	-	-	3	2	-	-	-
CO 5	-	-	-	-	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	√	√		√

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSCPOC304**				
Course Title	Analytical Methods in 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	Knowledge in basic analytical principles and knowledge in Spectroscopic techniques.				
Course Summary	This course provides knowledge about analytical techniques in chemistry and spectroscopic analysis.				

Detailed Syllabus:

Module	**Unit**	**Contents**	**45 Hrs**
I	**Introduction to analytical chemistry**		**9**
	1	Overview of analytical methods and their importance in chemistry.	2
	2	Introduction of analytical chemistry, Principles of Volumetric Analysis, Standard solutions- Preparation of Standard solutions, Normality, Molarities, Volumetric Correlations.	3
	3	Errors and treatment of analytical data- determinate error and indeterminate error, Inorganic qualitative analysis – ionic nature of reactions, common ion effect, applications, solubility product, ionic product, applications of solubility products, micro scale analysis, Quantitative analysis: theory of titration, primary and secondary standards.	3
	4	Analytical reagents used in chemical and spectro photometric analysis: Introduction, advantages, list of reagents: Barton-Marshall reagents, Dimedone, Cinnamaldehyde, Lucas reagent, Molybdenum Blue.	2
II	**Titrimetric analysis**		**9**
	5	Theory of acid-base titrations or neutralisation reactions, titration of strong acid against strong base, titration of weak acid against strong base, titration of a weak base with a strong acid, theory of acid base indicators, phenolphthalein and methyl orange indicators.	3
	6	Redox titrations: theory of titration, theory and example of permagnometry and Dichrometry, internal indicator, external indicator, theory of redox indicators, iodimetry and iodometry.	3
	7	Complexometric titrations: theory of complexometric titrations, matallochromic indicators, types of EDTA titrations- direct titration, back titration and replacement titration, adsorption indicators Colorimetric method-Theory and application.	3

III	**Chromatographic Methods**		**9**
	8	Introduction of chromatography, classification of chromatographic methods- adsorption chromatography, partition chromatography, exchange chromatography, molecular exclusion chromatography.	3
	9	Column chromatography- adsorption chromatography and its applications, thin layer chromatography (TLC), Paper chromatography- ascending paper chromatography, descending paper chromatography, radial paper chromatography.	3
	10	Ion exchange chromatography, gas chromatography- High performance liquid chromatography [HPLC] - Theory, classifications and instrumentation.	3
IV	**Spectroscopic Methods**		**9**
	11	Overview of spectroscopic techniques in chemistry. UV-Visible spectroscopy – UV-Vis Spectroscopy principle, Beer-Lambert Law, instrumentation, Applications of UV-Vis Spectroscopy, advantages and disadvantages.	3
	12	Infrared Spectroscopy: Definition, principle of IR spectroscopy, instrumentation of IR spectroscopy, Application of IR spectroscopy. Mass Spectroscopy: Definition, Principle of mass spectroscopy, instrumentation and its working and applications.	3
	13	Atomic absorption spectroscopy (AAS) - principle, theory, instrumentation of AAS and its applications. Atomic Emission Spectroscopy (AES): introduction, principle, advantages and disadvantages of mass spectroscopy, applications.	1
	14	Flame Emission Spectroscopy – principle, theory and instrumentation of flame emission spectroscopy and its applications.	2
V	**Thermoanlytical Methods of Polymers.**		**9**
	15	Thermal analysis – Definition, Characteristics of thermal analysis, conformation of thermal analysis and instrumentation of thermal analysis in polymers.	2
	16	DTA and DSC – Principle, Instrumentation, Calibration and Sample preparations.	3
	17	Thermogravimetry - Introduction, Thermo balance, Derivative Thermogravimetry (DTG), Intercomparison of TG and DTA, Applications of thermal analysis, Tg of polymers.	3
	18	Other Thermal Analysis – MS, FTIR, GC.	1

Analytical methods in Chemistry Practical– 30 Hours

Detailed Syllabus:

Module	**Contents**	**Hrs**

	Complexometry	14
1	Estimate volumetrically the concentration of Zn EDTA.	3
2	Estimate volumetrically the concentration of Mg EDTA.	3
3	Estimate volumetrically the concentration of Ni using EDTA.	4
4	Estimate volumetrically the hardness of water and concentration of Ca in water samples using EDTA.	4
	Colorimetric estimation	16
1	Estimate colorimetrically the concentration of Chromium – (using Diphenyl carbazide)	4
2	Estimate colorimetrically the concentration of Iron (using thioglycollic acid), Iron (using thiocyanate)	4
3	Estimate colorimetrically the concentration of Manganese (using potassium periodate),	4
4	Estimate colorimetrically the concentration of Nickel (using dimethyl glyoxime).	4

References:

1. J. E. Huheey, Inorganic Chemistry- Principles of Structure and Reactivity, Harper Collins College Publishing, 4th edition, 2011.
2. K. F. Purcell, J. C. Kotz, Inorganic Chemistry, Saunders, 1977.
3. S. F. A. Kettle, Physical Inorganic Chemistry, Oxford University Press, 1st edition, 1998.
4. Shriver, Atkins, Inorganic Chemistry, Oxford University Press, 2010.
5. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 5th edition, 1989.
6. D. A. Skoog, D. M. West and F. J. Holler, Fundamentals of Analytical Chemistry, 10^{nth} edition, 2021.
7. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 4th edition, 1978. 8. A. I. Vogel, A Text Book of Qualitative Inorganic Analysis, Longman 5th edition, 1979.
9. W. G. Palmer, Experimental Inorganic Chemistry, Cambridge University Press, 1962.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the analytical techniques and skill development in analytical field. Study the analytical reagents.	**U, An**	**1,2**
CO-2	Acquire skills in handling laboratory equipment and chemicals.	**U, Ap**	**1,2**
CO-3	Recognize the diverse applications of analytical methods in chromatography	**U, Ap, C**	**3,7**
CO-4	Enhance their knowledge of spectroscopic methods in inorganic chemistry.	**R, Ap, An**	**2,7**
CO-5	Apply TG, DTA and DSC in the study of polymers.	**R, Ap, An**	**1,2**

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

Name of the Course: Credits: 3:0:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO1	Understand the analytical techniques.	**1/1,2**	**U, An**	**F, C**	**L**	**P**
CO2	Acquire skills in handling laboratory equipment and chemicals.	**1/1,2**	**U, Ap**	**P**	**L**	**P**
CO3	Recognize the diverse applications of analytical methods in chromatography	**6/3,7**	**U, Ap, C**	**F,C**	**L**	
CO4	Enhance their knowledge of spectroscopic methods in inorganic chemistry.	**1/2,7**	**R, Ap, An**	**P,F**		**P**
CO5	Apply TG, DTA and DSC in the study of polymers.	**1/1,2**	**R, Ap, An**	**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	PSO 7	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-	1	-	2	-	-	-

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

Discipline	POLYMER CHEMISTRY
Course Code	**UK5DSCPOC305**
Course Title	Inorganic 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	Introductory Inorganic Chemistry
Course Summary	This course is designed to offer a comprehensive understanding of Nuclear Chemistry, analytical data evaluation, solid-state chemistry, the extraction of metals from ores, and the study of Inorganic Polymeric Materials

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Nuclear chemistry**	**12**
	1	Structure of nucleus - liquid drop model, shell model, forces in the nucleus, stability, ratio of neutrons to protons, magic numbers	3
	2	Equation of radioactive decay and growth. Half-life and average life. Radioactive equilibrium. Transient and secular equilibria.	3
	3	Nuclear reactions: Direct nuclear reactions, heavy ion induced nuclear reactions, photonuclear reactions. Neutron captures cross section and critical size.	3
	4	Nuclear fission as a source of energy, nuclear chain-reacting systems. Principle of working of the reactors of nuclear power plants. Breeder reactor. Nuclear fusion reaction, stellar energy.	3
II		**Evaluation of Analytical data**	**12**
	5	Evaluation of analytical data: Accuracy and precision. Standard deviation, variance and coefficient of variation. Student ‘t’ test, ‘Q’ test, and ‘F’ test.	4
	6	Errors: Classification, distribution, propagation, causes and minimization of errors. Significant figures and computation rules.	4
	7	Correlation analysis: Scatter diagram. Correlation coefficient, r. Calculation of r by the method of least squares.	4
III		**Solid State Chemistry**	**12**

	8	Isotropy and Anisotropy, Space Lattice and Unit Cell. Elements of Symmetry of Crystal.	3
	9	Crystal Systems, Bravais Lattices. Laws of Crystallography, Miller Indices, Representation of Lattice Planes of Cubic Crystals.	3
	10	Diffraction of X-rays by Crystals: Braggs' Equation-Derivation and Application. Identification of Type of Cubic Crystal. Rotating Crystal and Powder Method. Structure of NaCl, KCl and CsCl.	4
	11	Defects in Crystals - Schottky and Frenkel Defects.	2
IV	**Metallurgy**		**12**
	12	Brief overview of ore concentration processes; calcination and roasting.	3
	13	Electrometallurgy- Metallurgy of Aluminium, Sodium	2
	14	Pyrometallurgy- Iron and Zinc	3
	15	Hydrometallurgy- Gold and Silver	1
	16	Purification of crude metal- Distillation, Liquation, Zone refining, Electro refining, Chromatographic techniques and Vapour phase refining (Mond's process and Van Arkel process)	3
V	**Inorganic Polymers**		**12**
	17	Types of inorganic polymers, comparison with organic polymers	3
	18	Synthesis and structural aspects of silicones, siloxanes and silicates	4
	19	Synthesis and structural aspects of Borazines, phosphazenes, and polysulphates.	3
	20	Industrial applications of Inorganic Polymers	2

Reference

1. J. D. Lee, Concise Inorganic Chemistry, 5th Edn. Oxford University Press, 2018.
2. B. R. Puri, L. R. Sharma, K.C. Kalia, Principles of Inorganic Chemistry, 33rd Edn., Vishal Publishing Co., 2020.
3. S. Prakash, G. D. Tuli, S. K Basu, R. D. Madan, Advanced Inorganic Chemistry, Vol. 1 & 2, 17th Edn., S Chand, 2000.
4. H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Edn., New Age International Private Limited, 2011
5. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., Wiley, India (P) Ltd. 1999.

6. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi. Inorganic Chemistry, 4^{th} Edn. Pearson, 2006.
7. V. Cahndrasekhar, Inorganic and Organometallic Polymers, Springer-Verlag Berlin Heidelberg, 2005.
8. L. V. Azaroff, Introduction to Solids, McGraw Hill Education, 2017.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of Nuclear Chemistry, analytical data evaluation, solid-state chemistry, the extraction of metals from ores, and the study of Inorganic Polymeric Materials	**U**	**1**
CO-2	Understand the different nuclear models and the phenomenon of radioactivity	**U**	**2**
CO-3	Distinguish between types of nuclear reactions.	**U**	**1, 2**
CO-4	Identification of the errors which can happen in analysis	**U, An**	**1, 2**
CO-5	Differentiate between amorphous and crystalline solids, understand anisotropy, symmetry and types of crystals, Xray diffraction methods of study of crystal structure, identify the imperfections in crystals	**U**	**1**
CO-6	Representation of lattice planes and calculation of interplanar spacing, draw the crystal structures of NaCl and CsCl	**A**	**2**
CO-7	Understand inorganic polymers and their applications.	**U**	**5**

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

Note: 1 or 2 COs/module

Name of the Course 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)
CO-1	Understanding	**1 / 1, 6**	**U**	**F**	**L**	

	of Nuclear Chemistry, analytical data evaluation, solid-state chemistry, the extraction of metals from ores, and the study of Inorganic Polymeric Materials					
CO-2	Understand the different nuclear models and the phenomenon of radioacitivity	**2 / 1, 6**	**U**	**C**	**L**	
CO-3	Distinguish between types of nuclear reactions.	**1, 2/ 1, 6**	**U**	**P**	**L**	
CO-4	Identification of the errors which can happen in analysis	**1, 2/ 1, 2, 6**	**U, An**	**P**	**L**	
CO-5	Differentiate between amorphous and crystalline solids, understand anisotropy, symmetry and types of crystals, Xray diffraction methods of study of crystal structure, identify the imperfections in crystals	**1/ 1, 2, 6**	**U**	**P**	**L**	
CO-6	Representation	**2/ 1, 2,**	**A**	**P**	**L**	

	of lattice planes and calculation of interplanar spacing, draw the crystal structures of NaCl and CsCl	**3, 6**				
CO-7	Understand inorganic polymers and their applications.	**5/ 1, 2, 6**	**U**	**F**	**L**	

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

Mapping of COs with PSOs and POs:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	2	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-
CO2	-	2	-	-	-	-	-	-	2	-	-	-	-	1	-	-
CO3	1	2	-	-	-	-	-	-	2	-	-	-	-	1	-	-
CO4	1	2	-	-	-	-	-	-	2	1	-	-	-	1	-	-
CO5	1		-	-	-	-	-	-	2	1	-	-	-	1	-	-
CO6	-	2	-	-	-	-	-	-	2	1	2	-	-	1	-	-
CO7	-	-	-	-	2	-	-	-	2	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	✓	✓		✓
CO 6	✓			✓

Detailed Syllabus:

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSCPOC306**				
Course Title	Physical Chemistry IV				
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	Knowledge in state of matter, kinetics. Knowledge in Rheology of polymer.				
Course Summary	To study the basic concept of thermodynamics and kinetics. Apply the knowledge of states of matter.				

Module	**Unit**	**Content**	**Hrs**
I	**Chemical Kinetics**		**12**
	1	Order and molecularity of reaction. Derivation of integrated rate equation of zero, first, second, third and nth order reactions and examples.	3
	2	Determination of order of reactions: - Graphical and analytical methods use integrated rate equations, Fractional life- method, Differential rate equation method, Isolation method.	3
	3	Kinetics of complex reactions: Derivation of rate equations of (a) opposing reactions when both forward and backward reactions are of first order. (b) First order consecutive reactions. (c) Parallel reactions forming two products with first order rate process. Qualitative idea of chain reactions.	3
	4	Influence of temperature on rate of reaction: Arrhenius equation, Determination of Arrhenius parameter, Energy of activation and its significance. Collision theory, Derivation of the rate equation for a second order reaction based on collision theory, Unimolecular reactions- Lindeman mechanism, steady state approximation. Theory of absolute reaction rate.	3
II	**States of Matter**		**12**
	5	Introduction of states of matter – definition of matter, classification of matter: pure substances and mixtures. Properties of matter: mass, volume, density. Over view of states of matter: solids, liquids, gases and plasma.	3
	6	Solid state: characteristics of solids, types of solids: crystalline and amorphous, crystal lattice structure and unit cells, mechanical	3

		properties of solids: elasticity, plasticity, hardness. Phase diagrams and phase transitions involving solids.	
	7	Liquid state: properties of liquids: viscosity, surface tension, capillary action. Intermolecular forces in liquids: hydrogen bonding, van der waals forces. Phase transition involving liquids: melting, freezing, boiling, condensation. Vapor pressure and evaporation.	3
	8	Gaseous state: kinetic molecular theory of gases. Gas laws: Boyle's law, Charles's law, Avogadro's law, ideal gas equation. Deviation from ideal gas behaviour.	3
III	**Thermodynamics III**		**12**
	9	Nernst heat theorem, proof and its consequences. Statement of IIIrd 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.	4
	10	Statistical thermodynamics: introduction, types of statistics MB, BE and FD. 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.	4
	11	Thermodynamic functions in terms of partition functions - internal energy, enthalpy, pressure, work function and free energy function.	4
IV	**Surface Chemistry**		**12**
	12	Types of adsorption, heat of adsorption and its determination, difference between chemisorptions and physisorption.	3
	13	Factors influencing adsorption – Freundlich adsorption isotherm – Langmuir adsorption isotherm (derivation). The BET theory (no derivation) – use of BET equation for the determination of surface area. Adsorption from solutions- Gibb's adsorption equation and its verification. Applications of adsorption.	5
	14	Definition of colloids. Solids in liquids (sols), preparation, purification, properties - kinetic, optical, electrical. Stability of colloids, Hardy-Schulze law, protective colloid. Liquids in liquids (emulsions) preparation, properties, uses. Liquids in solids (gels) preparation, uses.	4
V		**Electrical and Rheological properties of Polymers**	**12**
	15	Electrical Conductivity in Polymers- Intrinsic and Extrinsic conductivity, conduction mechanisms (Ohmic, hopping, percolation), factors affecting conductivity (temperature, doping, morphology).	4
	16	Dielectric properties of polymers- polarization mechanism, dielectric constant and loss, frequency and temperature dependence, application in capacitors, insulators and sensors.	4
	17	Rheological behaviour of polymers – viscosity and visco elasticity, rheological model (Newtonian, Non-Newtonian, viscoelastic), shear and elongated rheology, influence of molecular structure, temperature and processing condition. Rheology in polymer processing. (Extrusion, injection moulding).	4

References:

1. E. N. Yeremin, Fundamentals of Chemical Thermodynamics, MIR Publishers 1981.
2. S. Glasstone, Thermodynamics for Chemists, East –West Press Private Ltd., New Delhi.
3. R. A. Albert, R. J. Silby, Physical Chemistry, Wiley Eastern, 2004.
4. K. J. Laidler, Chemical kinetics, 3rd Edn. Harper & Row, 1987.
5. C. Kalidas, Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, New Age International, 2005.
6. J. W. Moore, R. G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, 1981.
7. J. Rajaram, J. C. Kuriakose, Kinetics and Mechanisms of Chemical Transformations, Macmillan India, 2000.
8. G. W. Castellan, Physical Chemistry, Addison-Lesley Publishing, 1983.
9. Puri, Sharma, Pathania, Principles of physical Chemistry, Vishal publishing company, 2013.
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12. B. K. Sharma, Electrochemistry, Krishna Prakashan, 1985.
13. F. W. BillmeyerJr., Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.
14. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, New Age Publishers, 1988.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding the order of reactions.	**U, An**	**1,2**
CO-2	Understanding the basics concepts involved in colloids, chemical kinetics.	**U, Ap**	**1,2**
CO-3	Apply laws of thermodynamics in physics and chemical systems.	**R, U**	**1,2**
CO-4	Describe the electrical properties of polymers and their applications	**U, R**	**5**
CO-5	Analyse the rheological properties of the polymers and their significance in processing and applications.	**An, Ap**	**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	Understanding the order of reactions.	**1/1,2**	**U, An**	**F, C**	**L**	
2	Understanding the basics concepts involved in colloids, chemical kinetics.	**1/1,2**	**U, Ap**	**P**	**L**	
3	Apply laws of thermodynamics in physics and chemical systems.	**2/2,5**	**An, Ap**	**M,P**	**L**	
4	Describe the electrical properties of polymers and their applications	**1/2,5**	**An, Ap**	**C,P**	**L**	
5	Analyse the rheological properties of the polymers and their significance in processing and applications.	**2/2**	**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	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	-	-	-	-	2	-	-	-	-	-
CO 2	2	3	-	-	-	-	2	-	-	-	-	-
CO 3	-	2	1	-	-	-	-	2	-	-	-	-
CO 4	-	-	1	-	3	-	2	-	-	-	-	-
CO 5	-	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		✓	✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSEPOC301**				
Course Title	Polymer Waste Management				
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	Basic knowledge in organic chemistry and polymers.				
Course Summary	To impart a better knowledge on types of wastes, the ways to collect, segregate and manage it.				

Detailed syllabus:

Module	Unit	Content	Hrs
I		**Introduction to waste management**	**12**
	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.	3
	3	Zero waste initiatives, zero waste cities and Countries-brief discription.	3
	4	Circular economy concept, Sustainable materials, bioplastic products, applications, advantages, types, current uses, future scope.	3
II		**Different types of wastes and its management**	**12**
	5	Biodegradable waste and non biodegradable waste management, Biomedical waste management, biomedical waste management rule 2018.	2
	6	Chemical waste management- sources and various treatment methods- ion exchange, precipitation, oxidation and reduction and neutralization.	3
	7	E-waste management, E-waste recycling process, E-waste management rule 2016, Glass waste management-sources and methods- recycling process.	3
	8	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		**Plastic Waste Management-I**	**12**
	9	Imortance of plastics in daily life, its drawbacks, plastic pollution and consequences.	3

	10	Understanding of plastic waste- classification, sources, collection, segregation, identification and techniques used for its separation.	3
	11	Recycling and its types and stages, advantages of plastic recycling. Additives for improving the quality of recycled products.	3
	12	Exposure to environmental issues associated with plastic waste and guidelines and legislation in India for plastics wastes and recycling.	3
IV	**Plastic Waste Management-II**		**12**
	13	Thermoplastic waste management: 4 R’s approach (reduces, reuse, recycle, recover).	3
	14	Recycling classification - primary, secondary, tertiary, quaternary recycling with examples (mechanical, chemical and thermal processes).	3
	15	Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification.	3
	16	On-site disposal methods, compacting and baling.	3
V	**Liquid Waste Management**		**12**
	17	Sewage and sullage, health aspects of sewage, aim of sewage treatment.	3
	18	Sewage treatment plant – an outline and process for sewage treatment.	3
	19	Effluent treatment plant, need of effluent treatment plant, design of effluent treatment plant, treatment levels and mechanism.	3
	20	Septage treatment systems, process - different processes adopted for the treatment- brief discussion.	3

References

1. Gilbert M. Masters and Wendell P., Introduction to Environmental Engineering and Science, Pearson Publishers, 2014.
2. Ranjith K. Dani and Tanvi Arora, Waste Management and Sustainable Development, CRC Press Publishers, 2019.
3. Paul T. Williams, Waste Treatment and Disposal, John Wiley & Sons Inc., 2005,
4. Naomi B. Klinghoffer, Marco J. Castaldi, Waste to Energy Conversion Technology, Woodhead Publishing Ltd; 2018.
5. Blow S., Handbook of Rubber Technology, Hanser Gardner Publishers. 2000.
6. Daniel Klempner, Virendra G. Kebble., Handbook of Polymer Waste Management. Wiley Publishers, 2002.
7. Trevor M. Letcher, Plastic Waste and Recycling: Environmental Impact, Societal Issues, Prevention, and Solutions, Academic Press Publishers, 2020.
8. John Scheirs, Walter Kaminsky, Polymer Recycling: Science, Technology, and Applications, Wiley Publishers, 1998.
9. Michael Niaounakis., Plastics Waste: Feedstock Recycling, Chemical Recycling and Incineration, Elsevier Publishers, 2006.
10. D.S. Bhargava, N. Mathur., Biomedical Waste Management: A Review., CRC Press Publishers, 2018.

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.	**R, U**	**8**
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.	**U**	**1**
CO-3	Explain the importance of plastics in daily life, its drawbacks, plastic pollution and consequences.	**R, An**	**8**
CO-4	Exposure to environmental issues associated with plastic waste and guidelines and legislation in India for plastics wastes and recycling.	**U**	**6**
CO-5	Discuss sewage and sullage, health aspects of sewage, aim of sewage treatment.	**U**	**6**

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

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain the classification, properties and importance of scientific waste management, Climate change and waste, major environmental impacts.	**7/8**	**R, U**	**F, C**	**L**	
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.	**1/1**	**U**	**F**	**L**	
CO-3	Explain the importance of plastics in daily life, its drawbacks, plastic pollution and consequences.	**1/8**	**R, An**	**M**	**L**	

CO-4	Exposure to environmental issues associated with plastic waste and guidelines and legislation in India for plastics wastes and recycling.	**5/6**	**U**	**C**	**L**	
CO-5	Discuss sewage and sullage, health aspects of sewage, aim of sewage treatment.	**2/6**	**U**			

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

Mapping of COs with PSOs and POs :

	PSO-1	PSO-6	PSO-8	PO-1	PO-2	PO-5	PO-7
CO 1	-	-	2	-	-	-	2
CO 2	3	-	-	2	-	-	-
CO 3	-		3	3	-	-	-
CO 4	-	2	-	-	-	2	-
CO 5	-	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		✓		✓

<table>
<tr><td>Discipline</td><td colspan="5">POLYMER CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK5DSEPOC302</td></tr>
<tr><td>Course Title</td><td colspan="5">Plastics and Fiber Technology</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 hours</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic Chemistry and Material Science and knowledge of various polymer processing techniques</td></tr>
<tr><td>Course Summary</td><td colspan="5">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.</td></tr>
</table>

Detailed Syllabus:

<table>
<tr><th>Module</th><th>Unit</th><th>Content</th><th>Hrs</th></tr>
<tr><td rowspan="6">I</td><td colspan="2">Mixing and compounding</td><td>9</td></tr>
<tr><td>1</td><td>Introduction to plastic processing, additives for plastics – Fillers-(reinforcing and non-reinforcing).</td><td>1</td></tr>
<tr><td>2</td><td>Antioxidants, Stabilisers, Colourants, Flame retardants, Plasticisers- definition, significance and example</td><td>3</td></tr>
<tr><td>3</td><td>Mixing and compounding of plastics-process in brief.</td><td>1</td></tr>
<tr><td>4</td><td>Mixing and compounding equipments- Compounding by batch mixer.</td><td>2</td></tr>
<tr><td>5</td><td>High speed mixer - Two roll mill - Banbury Mixer - Ribbon blender - Planetary mixers.</td><td>2</td></tr>
<tr><td rowspan="6">II</td><td colspan="2">Moulding techniques I</td><td>9</td></tr>
<tr><td>6</td><td>Plastic injection moulding, different types of injection moulding machines.</td><td>1</td></tr>
<tr><td>7</td><td>Details of injection moulding machine, injection moulding of thermosets.</td><td>2</td></tr>
<tr><td>8</td><td>Extrusion- details of extruders, twin screw extruders, dies, post extrusion processing.</td><td>2</td></tr>
<tr><td>9</td><td>Calendaring- 2two roll, three roll calenders. Laminating- process in brief.</td><td>2</td></tr>
<tr><td>10</td><td>3D printing- process in brief and its applications.</td><td>2</td></tr>
</table>

III	**Moulding technique II**		**9**
	11	Compression moulding: hydraulic presses, press capacity and pressure calculations, moulding process- (brief description of the process).	1
	12	Transfer moulding: Moulding process and advantages	2
	13	Blow moulding: extrusion and injection blow moulding (process and applications)	2
	14	Rotational moulding: process and equipment (explanation with diagram)	2
	15	Reaction injection moulding: introduction, process and advantages.	2
IV	**Reinforced plastics**		**9**
	16	Reinforced plastics- definition, importance and application	2
	17	Processing techniques- Brief description of techniques such as hand lay-up, spray lay up, filament winding autoclave and bag moulding.	7
V	**Fiber technology**		**9**
	18	Fibers from cellulose and its derivatives	1
	19	Brief description different types of fibres like- polyolefinic, polyester, polyamide, aramide, carbon and glass fibers	2
	20	Methods of Fiber production/fibre spinning operation- dry spinning, wet melt spinning and electro spinning (process with diagram)- its advantages and disadvantages	2
	21	Different types of cords used in tyre industry-properties of fibers like denier, tex, tenacity, crimp (definition)	2
	22	Different types of twisting- mention the types, geo textiles. Natural Fibers in Kerala and their blended products- coir based fibre product-application.	2

Plastics and Fiber Technology Practicals **Practicals (30 hrs)**

Module	Unit	Content	Hrs
I	**HANDS ON TRAINING ON PLASTICS AND FIBER TECHNOLOGY**		**30**
	1	Hands on training in production of injection moulded plastic articles	4
	2	Hands on training in production of blow moulded plastic articles	4

	3	Hands on training in production of compression moulded plastic articles	4
	4	Hands on training in production of injection moulded plastic articles	4
	5	Case study on variation in properties of molded Polymer products by varying different additives	4
	6	Case study on variation in properties of reinforced plastics products by varying different reinforcing methods	5
	7	Case study based on fibre technology based industries.	5

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. V. R Gowariker, N. V. Viswanathan, Jayadev Sreedhar, Polymer Science, 3rd Edn. New Age International Publishers, 1996.
8. B. K. 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**	**5**
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**	**5**
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**	**5**
CO-4	Explain the concept of reinforced plastics and the materials processing techniques used and the the processes involved in hand lay-up, spray lay-up, filament winding, autoclave molding, and bag molding	**R**	**1**

CO-5	Identify different types of fibers used in industries and different fiber spinning operations, twisting techniques and the manufacturing process of various types of cords used in the tire industry. Understand the measurement parameters of fibers and the applications of geotextiles.	**U, An**	**5**
CO-6	Hands on training in production of moulded plastic articles using various moulding techniques and a case study	**Ap**	**4**

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

Name of the Course: Plastics and Fiber Technology; Credits: 3:0:1(Lecture:Tutorial:Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
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	**1/5**	**U**	**F, C**	**L**	
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	**3/5**	**An**	**F**	**L**	
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	**6/5**	**U**	**C**	**L**	
CO-4	Explain the concept of reinforced plastics and the materials processing techniques used and the the processes involved in hand lay-up, spray lay-up, filament winding, autoclave molding, and bag molding	**1/1**	**R**	**C**	**L**	
CO-5	Identify different types of fibers used in industries and different fiber spinning operations, twisting techniques and the manufacturing process of various types of cords used in the tire industry. Understand the measurement parameters	**7/5**	**U, An**	**F, C**	**L**	

	of fibers and the applications of geotextiles.					
CO-6	hands on training in production of moulded plastic articles using various moulding techniques and a case study	**3,2/4**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs

	PSO-1	PSO- 4	PSO-5	PO 1	PO 2	PO 3	PO 6	PO 7
CO 1	-	-	2	2	-	-	-	-
CO 2	-	-	3	-	-	3	-	-
CO 3	-	-	2	-	-	-	2	
CO 4	2	-		2	-	-	-	-
CO 5	-	-	2	-	-	-	-	3
CO 6	-	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		✓		✓
CO-6	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSEPOC303**				
Course Title	Polymers for Biomedical Applications				
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 hours
Pre-requisites	Knowledge on Biomaterial, their uses and Biodegradable polymers				
Course Summary	To learn about the various processing techniques and their components. To learn the fundamentals of extrusion and different extrusion processes ofthermoplastics				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Basics to Biomaterials**	**12**
	1	Significance and classifications of biopolymers and natural polymers	4
	2	Properties and applications of biopolymers and natural polymers such as Starch, cellulose, chitosan, gelatine, protein, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose	4
	3	Isolation, processing of biopolymers: composite formation, blending and solvent casting.	4
II		**Polymers as Biomaterials**	**12**
	4	Important features for Biomedical Application: responsiveness, estimations of biodegradationand biocompatibility	4
	5	Polyester and polysaccharides, natural gums,	4
	6	Biodegradable polymers, and their Importance, hydrogel, fibres, bio-ceramics, bio-elastomers and membrane	4
III		**Polymers in Biomedical Application**	**12**
	7	Permanent implants for function-orthopaedics (Internal and External artificial organ), cardio vascular, respiratory patches and tubes,	4
	8	Digestive system, genitourinary system, nervous system, orbital (corneal and lens prosthesis)–permanent implant for cosmoses	4
	9	Other applications of engineered material in clinical practices, silicone implants.	2
	10	Polymer membranes, polymer skin, polymeric blood	2
IV		**Lenses and Dental Application**	**12**

	11	Contact Lenses, Hard Lenses, Gas Permeable Lenses, Flexible Lenses, Soft Lenses, Hydrogels,Equilibrium Swelling,	2
	12	Absorption And Desorption, Oxygen Permeability, Types of Soft Lenses, Manufacture, Cleaning And Disinfection.	2
	13	Dental applications, denture bases, crown and bridge resins, plastic teeth	3
	14	Mouth protectors, maxillofacial prosthetic materials, restorative material, polyelectrolyte-based restoratives	3
	15	Sealants, adhesives, dental impression and duplicating materials, agar, algmater elastomers.	2
V	**Drug Delivery and Tissue Engineering**		**12**
	16	Introduction to drug delivery, polymers in controlled drug delivery	4
	17	Dressing strips, polymer drug vessels, core shell and nanogels,	4
	18	Polymers for antimicrobial activity, bio- conjugates tissue engineering, uses of cellulose, chitosan and alginate	4

References

1. Park, J. B, Bio-materials, An Introduction, CRC Press, 2003.
2. Tiwari A., Tiwari A., Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley, 2013.
3. Pilla S., Handbook of Bioplastics and Biocomposites Engineering Applications,Wiley, 2011
4. Ratner B.D., Hoffman A.S., An Introduction to Materials in Medicine,Academic Press, 1996.
5. Saltzman W.M., Drug delivery: Engineering principles for drug therapy, Oxford University Press, 2001.
6. Kalia S., Averous L., Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons, 2011.
7. Byrom D., Biomaterials: Novel Materials from Biological Sources, FirstEdition, Macmillan Publishers Ltd, 1991.
8. Bastioli C., HandBook of Biodegradable polymers, Rapra Technology, 1987.
9. Niaounakis M., Biopolymers: Processing and Products, First Edition, ElsevierInc, 2015.

Course Outcomes:

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

CO-1	Student acquire a knowledge on properties and applications of biopolymers and natural polymers its properties and applications	**U,R**	**1**
CO-2	Student learn about the basic concepts and requirement of biomedical applications and biocompatibility and about biodegradable polymers, and their Importance in many fields	**R,U**	**1**
CO-3	Student Understand about polymers in biomedical application- of engineered material in clinical practices, silicone implants , polymer membranes, polymer skin, polymeric blood	**R, U**	**1**
CO-4	Understanding on polymers used in Lenses and Dental applications	**R, U**	**1**
CO-5	Understanding on polymers in controlled drug delivery and its applications, Understand on polymers for antimicrobial activity and bio- conjugates tissue engineering	**U,Ap**	**8**

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

Name of the Course: Polymers for Biomedical Applications; Credits: 4:0:0 (Lecture: Tutorial:Practical)

CO No.	**Course Outcomes**	**PO/ PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Student acquire a knowledge on properties and applications of biopolymers and natural polymers its properties and applications	**3/1**	**U,R**	**F, C**	**L**	
CO-2	Student learn about the basic concepts and requirement of biomedical applications and biocompatibility and about biodegradable polymers, and their Importance in many fields	**3/1**	**R,Ap**	**F**	**L**	
CO-3	Student Understand about polymers in biomedical application- of engineered material	**4/1**	**R, U**	**C**	**L**	

	in clinical practices, silicone implants , polymer membranes, polymer skin, polymeric blood					
CO-4	Understanding on polymers used in Lenses and Dental applications	**3/1**	**R, U**	**C**	**L**	
CO-5	Understanding on polymers in controlled drug delivery and its applications, Understand on polymers for antimicrobial activity and bio-conjugates tissue engineering	**6/8**	**U,Ap**	**F, C**	**L**	

Mapping of COs with PSOs and POs :

	PSO-1	**PSO-8**	**PO-3**	**PO-4**	**PO-3**	**PO-6**
CO 1	2	-	2	-	-	-
CO 2	2	-	2	-	-	-
CO 3	3	-	-	-	-	-
CO 4	2	-	-	-	-	-
CO 5	-	3	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		✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5DSEPOC304**				
Course Title	Polymer Product Design				
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 hour	-	2 hour	5 hour
Pre-requisites	Basic knowledge in different moulding techniques				
Course Summary	To impart the basic concepts and theories of different moulding, calendaring techniques. It includes practical experiments in Plastic and Fibre Technology and providing students with hands-on experience in the laboratory.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Moulding techniques**	**9**
	1	Introduction of moulding techniques, Fundamental principles and operations of compression moulding	3
	2	Injection moulding	2
	3	Extrusion moulding, Operations of twin screw and single screw extruder	2
	4	Blow moulding and calendering process	2
II		**Injection moulded products**	**9**
	5	Injection moulding, advantages and disadvantages of injection moulding	3
	6	Different types of common injection moulded products-plastic bottles and containers	2
	7	Household appliances, kitchenware, automotive parts, medical devices	2
	8	Toys, plastic furniture, sports equipments and other applications	2
III		**Blow moulding applications**	**9**
	9	Blow moulding process, advantages and disadvantages of blow moulding	4
	10	Different product design of hollow articles by blow moulding techniques	5
IV		**Extrusion moulded products**	**9**
	11	Extrusion moulding process, plastic extrusion process	2
	12	Extrusion moulding materials, advantages and disadvantages	2
	13	Applications of extrusion process-pipes and tubing, wire insulation	2
	14	Window and door profile, windshield wipers and squeezes	2
	15	Other applications	1
V		**Calandered products**	**9**
	16	Calandering process, Making plastic film and plastic sheet	2
	17	Plastic materials used for calandering process, compound formulation	2
	18	Colouring materials and fillers, formulation for calandering	1

	19	Compound preparation- blending and fluxing, cooling and winding of sheets	2
	20	Advantages of calandering process, Applications- making plastic film and plastic sheet	2

Polymer Product Design Practical **30Hrs**

Module	Unit	Content	Hrs
I		**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	15
	2	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.	15

References

1. J. A. Brydson, Plastic materials,7th edition, Butterworth-Heinemann,1999.
2. D. C. Blackley, High polymer lattices, vol.1 and 2, Maclaren and sons,1966.
3. M. D. Baijlal, Plastics polymer science and technology, Wiley, 1982
4. Ulrich, T. K. T., Eppinger, D. S., Product design and development, TataMcGraw-Hill, 3rd edition, 2004.
5. Mahajan, M., Industrial Engineering and Production Management, DhanpatRai Publication, 2008.
6. Mollay, A. R. Plastic Part Design for Injection Moulding, Hanser Publishers,Munich Vienna, New York, 1994.
7. Hollins, B. Pugh, S., Successful product design, Butterworth & Co, 1990.
8. V. R. Gowariker, NV Viswanathan, Jayadev Sreedhar, Polymer Science, 3rd Edn. New Age International Publishers, 1996.
9. B. K. 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	Analysing the basic principles of different moulding techniques	**An**	**5**
CO-2	To study the injection moulding process and it's various applications	**U, Ap**	**5**

CO-3	Describe the blow moulding techniques and understanding the processing of hollow articles by blow moulding techniques	**R,U**	**1**
CO-4	Knowledge of extrusion process and understanding the advantages and disadvantages of extrusion process. Explain the applications of extruded product in different fields	**U**	**5**
CO-5	Describe the calandering process and understanding the product design by calandering process.	**U**	**5**
CO-6	hands on training in production of moulded plastic articles using various moulding techniques and a case study	**Ap**	**4**

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

Name of the Course: Polymer Product Design; Credits: 3:0:1(Lecture:Tutorial:Practical)

CO No.	Course Outomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Analysing the basic principles of different moulding techniques	**3/5**	**An**	**P**	**L**	
CO-2	To study the injection moulding process and it's various applications	**6/5**	**U, Ap**	**P,C**	**L**	
CO-3	Describe the blow moulding techniques and understanding the processing of hollow articles by blow moulding techniques	**7/1**	**R,U**	**C**	**L**	
CO-4	Knowledge of extrusion process and understanding the advantages and disadvantages of extrusion process. Explain the applications of extruded product in different fields	**5/5**	**U**	**C, P**	**L**	
CO-5	Describe the calandering process and understanding the product design by calandering process.	**2/5**	**U**	**C, P**	**L**	
CO-6	hands on training in production of moulded plastic articles using various moulding techniques and a case study	**3,2/4**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs :

	PSO-1	PSO-4	PSO-5	PO-2	PO-3	PO-5	PO-6	PO-7
CO 1	-	-	3	-	3	-	-	-
CO 2	-	-	3	-			3	-
CO 3	2	-		-			-	2
CO 4	-	-	2	-		2		3
CO 5	-	-	2	2				
CO-6	-	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	✓		✓	✓

<table>
<tr><td>Discipline</td><td colspan="5">POLYMER CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK5SECPOC301</td></tr>
<tr><td>Course Title</td><td colspan="5">Polymer Processing</td></tr>
<tr><td>Type of Course</td><td colspan="5">SEC</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>3</td><td>3 hours</td><td>-</td><td>-</td><td>3 hours</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic knowledge in chemistry and knowledge in polymers.</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides information about polymer properties and processing. Detailed study about rubber compounding, elastomeric compounding and its processing are included. The course offers practical experience in processing of different polymers and latex.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Polymer properties and processing**		**9**
	1	Importance of polymers in everyday life. Classification of Polymers- Polymer structure – homopolymers and heteropolymers. Linear, branched, cross linked and network polymers. Physical properties of polymers - Crystalline melting point, Glass transition temperature. Factors affecting Tm and Tg.	3
	2	Properties of elastomeric, fibre and plastic materials. Structure -property relationship. Additives for compounding of thermoplastics and thermosets.	2
	3	Moulding processes: Compression moulding-injection moulding, blow moulding. Forming techniques- extrusion, calendaring, and casting. Lamination and microencapsulation. Fibre forming polymers, Fibre spinning techniques, Wet Dry and Melt spinning.	4
II	**Latex and Elastomer Processing I**		**9**
	4	Natural latex, synthetic latexes and their blends. Preservation, Principles of latex compounding. Accelerators, antioxidants, Fillers, Vulcanizing agents, dispersing and Emulsifying agents, Stabilisers, Thickening agents Natural rubber latex - Processing. Product manufacture by different latex dipping processes.	4
	5	Synthetic latex. Extrusion, properties and products based on synthetic latex, Latex elastic threads; Latex tubing; Latex casting process. Application of synthetic latex- Surface coatings, Adhesives, Paper industries.	5
III	**Latex and Elastomer Processing II**		**9**
	6	Properties of rubber. Natural and synthetic rubber (NR, SBR, BR, IIR, IR, EPDM, Special purpose rubbers such as CR, NBR, fluorocarbon rubbers and Silicone rubber).	4

	7	Dry rubber compounding, Rubber processing steps, Mastication, Shaping and Vulcanization. Importance of Vulcanization - Rubber mixing mechanism - two roll mill, internal mixer.	3
	8	Reaction injection moulding of PU, Silicone injection moulding. Applications - Tyre technology.	2
IV	**Polymer processing and Analysis**		**9**
	9	a. Prepare polymeric sheet/ specimen by compression moulding. b. Prepare rubber bands, balloon etc. c. Determine tear strength, abrasion resistance of rubber compounds. d. Preparation of polymeric product by injection molding.	
V	**Advanced processing techniques**		**9**
	10	Introduction to 3D printing, Eelectrospinning, its technology and advantages. Visit to analytical laboratories and industries.	

References

1. Odian, George. Principles of Polymerization. Wiley, 2004.
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17. Gogos, C. G., Tadmor, Z., Principles of polymer processing. John Wiley & Sons, 2013.
18. Berins, M. (Ed.). Plastics engineering handbook of the society of the plastics industry. Springer Science & Business Media, 1991.

Course Outcomes

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

CO-1	Acquire a fundamental knowledge in latex, rubber, fiber and plastic technology.	**U**	**1,5**
CO-2	Know about additives used for compounding followed by compounding techniques.	**U**	**1**
CO-3	To familiarize with various latex compounds and product manufacturing methods.	**U**	**1**
CO-4	Be familiar with polymer processing techniques and know about important processes used for elastomers and fibers.	**U, Ap**	**5**
CO-5	Know about plastic processing technology which includes thermoplastics and thermosets.	**U, Ap**	**5**

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

Note: 1 or 2 COs/module

Name of the Course Polymer Processing: Credits: 3:0:0 (Lecture: Tutorial: Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Acquire a fundamental knowledge in latex, rubber, fiber and plastic technology.	**1/1,5**	**U**	**C**	**L**	
CO-2	Know about additives used for compounding followed by compounding techniques.	**1/1**	**U**	**C**	**L**	
CO-3	To familiarize with various latex compounds and product manufacturing methods.	**1,2/1**	**U**	**C**	**L**	

CO-4	Be familiar with polymer processing techniques and know about important processes used for elastomers and fibers.	**1/5**	**U**	**P**	**L**	
CO-5	Know about plastic processing technology which includes thermoplastics and thermosets.	**1/5**	**U**	**P**	**L**	

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**
CO 1	1	-	-	-	2	2	-	-	-	-
CO 2	2	1	-	-	-	2	-	-	-	-
CO 3	2	1	-	-	-	2	-	-	-	-
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
- Project Evaluation
- Final Exam
- Industrial visit and report

Mapping of COs to Assessment Rubrics:

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

Discipline	POLYMER CHEMISTRY				
Course Code	**UK5SECPOC302**				
Course Title	Biodegradable Polymers				
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 hours
Pre-requisites	Basic knowledge of polymers and general awareness about biodegradable polymers.				
Course Summary	This course provides information about biodegradable polymers, polymer recycling and product Manufacturing. Also covers Polymer assessing Methods and case studies.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Biodegradable polymers - Sustainability and Responsibility Approaches**	**9**
	1	Introduction, Properties, Examples – Poly glycolic acid (PGA), Poly Lactic acid (PLA), Poly caprolactone (PCL), Nylon-2-Nylon-6.	4
	2	Benefits and Disadvantages of Biodegradable polymers, Uses.	2
	3	Sustainability and responsibility in using and preparing polymers for various applications.	3
II		**Structures Favoring Biodegradability**	**9**
	4	Chemical degradation initiates biodegradation, Hydrolysis of synthetic biodegradable polymers.	3
	5	Development of relative starch technology, modifications, characterizations and applications.	3
	6	Thermal degradation, hydrolytic degradation, environmental degradation.	3
III		**Polymer Recycling and Product Manufacturing**	**9**
	7	Introduction, conventional recycling - recycling codes- recycling problems, degradable complicate recycling.	2
	8	Polyethylene/starch film, reprocessing polyethylene/cornstarch film scrap.	2
	9	Learning to reprocess PE/S, Calcium oxide moisture scavenger -Temperature control - Accounting for pro-oxidant - Handling PE/S repro, Economics of in-plant recycling, Using PE/S repro — comparative study of PE/S repro on film properties.	3

	10	Recycling other degradables. Reclaimed Rubber, Structure and uses	
IV		**Biodegradability in Polymers and Assessing Methods**	**9**
	11	Criteria used in the evaluation of biodegradable polymers, choosing the most appropriate methodology	2
	12	Description of current test methods, Screening test for biodegradability.	2
	13	Tests for inherent biodegradability, tests for simulation studies.	2
	14	Petri dish screen, Environmental chamber method, Cotton cloth method, Culture - Soil burial tests.	3
V		**Case study**	**9**
	15	Case studies on the biodegradability of various polymer products used in everyday life – Directions for doing the case study.	1
	16	Identifying problem and reviewing literature in regard with the study	4
	17	Discussion and Inference	2
	18	Result and conclusion	1
	19	Presentation of report	1

Reference

1. Abraham J. Donb & Others (ed.) Handbook of Biodegradable polymers, CRC Press, London, 1998.
2. G. J. L. Griffin, Chemistry & Technology of Biodegradable Polymers, Blackie Academic & Professional, New york, 1994.
3. Yoshiharu Doi, Kazuhiko Fukuda (ed.) Biodegradable Plastics & Polymers Elsevier, 1994.
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5. Chandrani Sarkar, Sampa Saha (ed.) Biodegradable Polymers and Their Emerging Applications, Springer Nature, Singapore, 2023.
6. G. Scott (ed.) Degradable Polymers, Principles and Applications, Springer Netherland, 2002.
7. E. S. Stevens, Green Plastics, An Introduction to the New Science of Biodegradable Plastics, Princeton University Press, 2020.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Will develop understanding on biodegradable polymers	**U**	**5**
CO 2	Will understand mechanism of degradation of polymers	**U**	**1**
CO-3	Will develop innovative ideas to create biofriendly polymers	**An, E, C**	**6,8**
CO-4	Will assess bio-degradability of polymers	**E**	**6, 8**

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

Note: 1 or 2 COs/module

Name of the Course: Credits: 3:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Will develop understanding on biodegradable polymers.	**1,2/5**	**U**	**F, C**	**L**	
CO- 2	Will understand mechanism of degradation of polymers.	**1/1**	**U** **U**	**P**	**L**	
CO-3	Will develop innovative ideas to create bio friendly polymers.	**1/6,8**	**An, E, C**	**M**	**T** **T**	**P**
CO-4	Will assess bio-degradability of polymers.	**1,2/6,8**	**EE**	**P**	**T**	**P**

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

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO5	PSO6	PSO8	PO1	PO2	PO3	PO4	PO5
CO 1	-	-	2	-	-	1	2	-	-	-
CO 2	2	-	-	-	-	2	-	-	-	-
CO 3	-	-	-	2	1	2	-	-	-	-
CO 4	-	-	-	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	Industrial Visit
CO 1	✓			✓	
CO 2	✓			✓	
CO 3	✓			✓	
CO 4		✓	✓	✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSCPOC301**				
Course Title	Inorganic 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
	3	3 hours	-	2 hours	5
Pre-requisites	Basic knowledge in Inorganic Chemistry				
Course Summary	This course offers a comprehensive study of Coordination compounds, organometallic compounds, Bioinorganic compounds and non-aqueous solvents. Additionally, it includes practical experiments in gravimetric analysis.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Coordination Chemistry I**	**9**
	1	Double salts & coordination compounds, nomenclature.	3
	2	Werner's theory, EAN rule, shapes of d orbitals	3
	3	Bonding in transition metal complexes- V. B. Theory, Crystal field theory - explanation of magnetic properties, geometry, and colour, electronic spectra of d^1 & d^9 systems.	3
II		**Coordination Chemistry II**	**9**
	4	Spectrochemical series, effects of crystal field splitting, Jahn – Teller distortion, M. O. theory, chelates – application.	3
	5	Isomerism & stability of complexes, factors affecting stability	3
	6	Geometry of different coordination numbers, application of complexes in qualitative & quantitative analysis.	3
III		**Organometallic compounds**	**9**
	7	Definition, nomenclature & classification, 18 electron rule.	3
	8	Metal carbonyls (mono nuclear & poly nuclear - examples of carbonyls of Fe, Co, & Ni).	3
	9	Bonding in ferrocene, structure & application of Ziese's salt, Wilkinson's catalyst. Application of organometallic compounds.	3
IV		**Bioinorganic Chemistry**	**9**
	10	Toxicity of metal ions (Pd, As, Cd, Mg), oxygen carriers, haemoglobin & myoglobin - structure & mechanism of action, cooperative effect in Hb, biochemistry of iron.	3
	11	Biological role of Mg & Ca ions, elementary idea of cytochromes, ferretin & ferredoxins	3
	12	Metallo enzymes –carbonic anhydrase & peroxidase, photosynthesis, principle & mechanism	3
V		**Non-aqueous solvents and Compounds of Non-Transition Elements**	**9**

	13	Non – aqueous solvents – Classification of solvents, characteristics of common solvents, protic & aprotic solvents,	3
	14	Liquid ammonia solutions of alkali metals, reactions in liquid SO_2 & liquid HF.	2
	15	Preparation, properties & structural aspects of following: boron nitrides, borazole, boron hydrides	2
	16	Chemistry of cement, glass, ceramics	2

Inorganic Chemistry III Practical 30hrs

Module	**Contents**	Hrs
I	**Precipitation and Filtration Techniques**	2
1	Washing of precipitate based on principle of solvent extraction	
2	Filtration using Whatman Filter paper	
3	Desiccating agents and use of desiccators and vacuum desiccators	
4	Incineration in silica crucible	
5	Use of sintered crucible and its advantages and limitations	
II	**Gravimetric Estimations**	18
A	**Estimations using silica crucible**	
1	Estimation of water of crystallization in hydrated Barium chloride	
2	Estimation of Barium as Barium sulphate	
3	Estimation of sulphate as Barium sulphate	
4	Estimation Iron as Fe_2O_3	
5	Estimation Calcium as $CaCO_3$	
B	**Estimations using sintered crucible**	10
1	Magnesium as oxinate	
2	Nickel as nickel dimethyl glyoximate	
3	Copper as copper thiocyanate	

References

1. J. D. Lee, “Concise inorganic chemistry”, Chapman & Hall India, 1991.
2. Sathya Prakash, G. D. Tuli, S. K. Basu & R. D. Madan, “Advanced Inorganic Chemistry”, Vol I, S. AB books. New Delhi, 2020.
3. F. A. Cotton, P. L. Gaus & G. Wilkinson, “Basic Inorganic Chemistry”, John Wiley & Sons, 1994.
4. B. R. Puri, L. R. Sharma & K. C. Kalia, “Principles of Inorganic Chemistry”, Vishal Publishing Co, New Delhi, 2020.
5. D. F. Shriver, P.W. Atkins & C. H. Langford, “Inorganic Chemistry”, Oxford Univ. Press, 1990.
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10. A.I Vogel, Vogel’s Textbook of quantitative analysis, Prentice Hall, 2000.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the properties, bonding, stability and factors affecting stability of complexes.	**U**	**1**
CO-2	Understand and apply spectrochemical series, CFSE and their consequences, Correlate geometry, stability and Jahn Teller effect and its causes	**U, Ap**	**1,2**
CO-3	Explain the organometallic compounds, the role of organometallic compounds in organic Synthesis.	**U**	**1**
CO-4	Discuss the role of inorganic ions in biological systems and biochemistry of haemoglobin, myoglobin, cytochromes, iron sulphur	**U**	**1**
CO-5	Explain the classification and characteristic of non-aqueous solvents and properties of compounds of non-transition elements.	**U**	**1**
CO-6	Develop skill in gravimetric analysis	**Ap**	**2**

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

Name of the Course: Inorganic 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	Understand the properties,	**1/1**	**U**	**C**	**L**	

	bonding, stability and factors affecting stability of complexes					
2	Understand and apply spectrochemical series, CFSE and their consequences, Correlate geometry , stability and Jahn Teller effect and its causes	**1/1**	**Ap**	**C**	**L**	
3	Explain the organometallic compounds, the role of organometallic compounds in organic Synthesis.	**1/2**	**U**	**C**	**L**	
4	Discuss the role of inorganic ions in biological systems and biochemistry of haemoglobin, myoglobin, cytochromes, iron sulphur	**1/1,3,4**	**U**	**C**	**L**	
5	Explain the classification and characteristic of non-aqueous solvents	**2/1**	**U**	**C**	**L**	
6	Understand precipitation techniques , Appreciate the	**2,3,6,8/4**	**Ap**	**P**		**P**

	application of silica crucible and sintered crucible in gravimetry, Practice technique of making, diluting solutions on quantitative basis.					

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

Mapping of COs with PSOs and POs :

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

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam

- Project Evaluation
- 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			✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSCPOC302**				
Course Title	Organic 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	4 hours	-	-	4
Pre-requisites	Basic knowledge in organic chemistry and spectroscopy				
Course Summary	This course provides information about stereochemistry and conformational analysis of organic compounds. It also covers natural product chemistry, carbohydrates, amino acids and proteins. It is also envisioned to provide concepts in organic spectroscopy and photochemical reactions. Also discusses about characterization techniques of polymers.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Stereochemistry**	**12**
	1	Conformations: Conformational analysis of ethane, n-butane and cyclohexane. Fisher, Newman, Saw-horse and Wedge projections. Conformational analysis of substituted cyclohexane, decalins. Effect of conformation on reactivity of cyclohexanes.	4
	2	Pro stereoisomerism, Stereo topicity, Prochiral centre and Prochiral faces - Pro R and Pro S, Re face and Si face. Atropisomerism in biphenyls. Stereoselectivity, Enantioselectivity, Diastereoselectivity, Stereospecific and Stereoselective synthesis.	4
	3	Conformational descriptors - factors affecting conformational stability of molecules. Conformation and reactivity of elimination reactions (dehalogenation, dehydrohalogenation, Saytzeff and Hofmann eliminations).	4
II		**Carbohydrates, Amino Acids, Proteins and Nucleic acids**	**12**
	4	Classification and nomenclature of monosaccharides, Configuration of monosaccharides, Epimerization, Mutarotation and Anomers. Structures elucidation of glucose and fructose. Chair conformation of D-glucopyranose.	4
	5	Amino acids: - Classification, Two methods of preparation and reactions of alpha-amino acids - Essential and non-essential amino acids. Zwitter ion and Isoelectric point.	4
	6	Peptides: structure and synthesis (Carbobenzoxy method, Sheehan method). Proteins: Structure of Proteins, Denaturation and Colour reactions. Nucleic acids: Classification and structure of DNA and RNA. Replication of DNA.	4
III		**Chemistry of Natural Products**	**12**

	7	Introduction to primary and secondary metabolites in plants. Extraction methods of chemical constituents from plants, such as fractionation using solvents, specific extraction of alkaloids and supercritical fluid extraction.	3
	8	Characterizations of compounds (terpenes, sterols, alkaloids, carbohydrates, flavonoids and poly phenols) by colour reactions and spray reagents.	3
	9	Determination of carbon skeleton of alkaloids (Hofmann, Emde and Von Braun degradation methods).	3
	10	Extraction and structural elucidation of conine, nicotine. Importance of quinine, morphine and codeine.	3
IV	**Organic Spectroscopy and Photochemistry**		**12**
	11	NMR spectroscopy – Principle of proton NMR – Shielding and deshielding effect, Chemical shift, Factors influencing chemical shift. Spin-spin splitting, Coupling constant, Interpretation of NMR spectrum of simple molecules like $CHBr_2CH_2Br$, ethylbromide, pure ethanol and impure ethanol, acetaldehyde and toluene.	6
	12	Structure elucidation of simple organic molecules using NMR spectroscopic techniques.	2
	13	Photochemical processes. Photochemical Vs Thermal reactions. Singlet and triplet states, Allowed and forbidden transition, Energy transfer, Sensitization and quenching.	2
	14	Photoreactions of carbonyl compounds-Norrish Type I and Type II reactions. Patterno Buchi reaction.	2
V	**Characterization Techniques of polymers**		**12**
	15	Infrared Spectroscopy (IR): Principle and theory. Applications-Establishment of chemical structure of polymers, Reaction kinetics, Polymer linkages, Hydrogen bond formation, Purity, Copolymerization.	4
	16	Nuclear Magnetic Resonance (NMR): (^{1}H and ^{13}C NMR) principle, theory, applications structure (chemical), purity, tacticity, etc.	4
	17	UV-Visible Spectroscopy: Principle and theory, Applications in qualitative and quantitative analysis, Purity, Cis-trans-conformation, Molecular weight determination. Polymer degradation analysis.	4

References

1. A. Bahl and B. S. Bahl, Advanced Organic Chemistry, 5th Ed., S. Chand & Company, New Delhi, 2012.
2. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press, 2002.
3. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 3rd Edn., New Age Pub., 2010.

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6. P. S. Kalsi, Spectroscopy of organic compounds, New Age International Publishers, 8th Edn., 2020.
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8. S. C. Sharma and M. K. Jain, Modern Organic Chemistry, Golden Jubilee Ed., Vishal Publishing Company, New Delhi, 2020.
9. I. L. Finar, Organic Chemistry Vol – 1, 5th Ed., Pearson Education, New Delhi, 2002.
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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding stereo chemistry and applications.	**U**	**1**
CO-2	Discuss about carbohydrates, amino acids, Proteins and nucleic acids.	**U**	**2**
CO-3	Discuss about natural products, its characterization and extraction.	**U**	**1**
CO-4	Discuss about organic spectroscopy and photochemical reactions	**U**	**1**
CO-5	Discuss about characterization of polymers using IR, NMR and UV-Visible spectroscopy.	**U**	**1**

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)

CO-1	Understanding stereochemistry and applications.	**1/1**	**U**	**C**	**L**	
CO-2	Discuss about carbohydrates, amino acids, Proteins and nucleic acids.	**1/2**	**U**	**C**	**L**	
CO-3	Discuss about natural products, its characterization and extraction.	**1/1**	**U**	**C**	**L**	
CO-4	Discuss about organic spectroscopy and photochemical reactions.	**1/1**	**U**	**C**	**L**	
CO-5	Discuss about characterization of polymers using IR, NMR and UV-Visible spectroscopy.	**1/1**	**U**	**C**	**L**	

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**
CO 1	2	-	-	-	-	2	-	-	-	-
CO 2	-	2	-	-	-	2	-	-	-	-
CO 3	2	-	-	-	-	2	-		-	-
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/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assig nment	Project Evaluatio n	End Semester Examinations	Industrial Visit
CO 1	✓	✓		✓	
CO 2	✓	✓		✓	
CO 3	✓	✓		✓	
CO 4	✓	✓		✓	
CO 5	✓	✓		✓	

Discipline	POLYMER CHEMISTRY
Course Code	**UK6DSCPOC303**
Course Title	Physical 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	Introductory Physical Chemistry
Course Summary	This course is designed to offer a comprehensive understanding in group theory, quantum mechanics, electrochemistry and fundamentals of spectroscopic methods.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Group Theory**	**12**
	1	Group theory: Elements of symmetry – Proper and improper axis of symmetry, plane of symmetry, centre of symmetry and identity element. Combination of symmetry elements.	4
	2	Determination of point groups of molecules- Acetylene, H_2O, NH_3, BF_3, $[Ni(CN)_4]^{2-}$.	3
	3	Symmetry operations. Order of a group. Combination of symmetry operations, Symmetry operations. Order of a group. Combination of symmetry operations. Group theoretical rules, Construction of Group multiplication table for C_{2V} point group.	5
II		**Quantum Mechanics**	**12**
	4	Radiation phenomena- blackbody radiation, photoelectric effect, Compton effect and atomic spectra. Plank's quantum theory.	2
	5	Concept of operators: Linear, Laplacian, Hamiltonian, and Hermitian operators. Postulates of quantum mechanics. Derivation of Schrodinger wave equation and its significance. Eigen functions and Eigen values.	4
	6	Application of quantum mechanics to simple systems-Particle in 1D and 3D box and its complete solution. Normalization of wave function, Concept of degeneracy. Schrodinger equation for H atom equation in Cartesian and spherical, polar co-ordinates (without derivation).	6
III		**Molecular Spectroscopy - I**	**12**
	7	Regions of electromagnetic spectrum, Interaction with matter, Quantization of energy- photon, various types of molecular excitation and types of molecular spectra. Born-Oppenheimer approximation.	2
	8	Rotational spectroscopy: Interaction between molecules and microwaves and criteria for microwave activity, rotation of molecules: Types of molecules according to moments of inertia-	5

		linear, Symmetric top, Asymmetric top and spherical top with examples each. Microwave spectroscopy of rigid diatomic molecules, Energy expression, Rotational constant, Rotational energy levels, Selection rule, Separation between spectral lines, Equation of J for maximum intensity (no derivation), Determination of bond length.	
	9	Vibrational spectroscopy: Criteria for IR activity, Simple Harmonic oscillator model; Hooks 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. Energy expression and Selection rules, Fundamental and Overtone transitions. Combination bands. Degree of freedom of polyatomic molecules.	5
IV		**Molecular Spectroscopy - II**	**12**
	10	Raman spectroscopy: Rayleigh and Raman Scattering, Stoke's and antistoke's lines and their intensity difference. Interaction between molecules and IR radiations and criteria for Raman activity, Induced dipole moment and polarizability, Pure Rotational Raman spectra. Selection rule. Frequency of separation, Vibrational Raman spectra, Selection rule, Rule of Mutual exclusion. Advantages of Raman Spectroscopy.	6
	11	Electronic spectroscopy of molecules: Selection rule, Vibrational Structure, Frank-Condon principle - Diagram, spectrum and continuum. Electronic spectra of polyatomic molecules (qualitative idea only), Different types of electronic excitations. Singlet and triplet states.	6
V		**Resonance Spectroscopy**	**12**
	12	NMR spectroscopy: Principle of NMR, nuclear spin. HNMR, Interaction of nuclear spin with external magnet. Energy level splitting, Precession. Chemical shift. Delta and tau scales. Presentation of NMR spectra, Low resolution spectra and high resolution spectra, Spin-spin coupling.	5
	13	Electron spin resonance spectroscopy: Principle, Types of substances with unpaired electrons. Interaction of electron magnet with external magnet, Energy level splitting, Lande splitting factor. Presentation of ESR spectrum, Normal and derivative spectra. Hyperfine splitting. Simple examples of methyl and benzene radicals.	5
	14	Mossbauer effect, Mossbauer energy levels with isomer shift. Quadrupole splitting and hyperfine interaction.	2

References

1. V. Ramakrishnan, M. S. Gopinathan, Group Theory in Chemistry, 2nd Ed., Vishal Publishing Co., 2013.
2. Puri, Sharma, Pathania, Priniciples of Physical Chemistry, 47th Ed., Vishal Publishing Co., 2020.
3. R. K. Prasad, Quantum Chemistry, 4th Ed., New Age International, 2020.

4. Mc Quarrie, J. D. Simon, Physical Chemistry – A molecular Approach, 1st Ed., Viva Books, 2019.
5. I. N. Levine, Physical Chemistry, Tata McGraw Hill, 2001.
6. P. W. Atkins, Physical Chemistry, 11th Ed., Oxford, University Press, 2018.
7. Banwell, C. N. &Mc Cash, E. M. Fundamentals of Molecular Spectroscopy,4th Ed. Tata McGraw-Hill: New Delhi, 2006.
8. Gurdeep Raj, Advanced Physical Chemistry, GOEL Publishing House, 2020.
9. Lowe, J. P. & Peterson, K. Quantum Chemistry, 3rd Ed., Academic Press, 2005.
10. Manas Chanda, Atomic structure and Chemical bonding in Molecular Spectroscopy, Tata McGraw Hill, 2019.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding of group theory and point groups.	**U**	**1**
CO-2	Discuss about quantum mechanics and its applications.	**U**	**2**
CO-3	Discuss about rotational and vibrational spectroscopy	**U**	**1**
CO-4	Discuss about Raman spectroscopy and electronic spectroscopy.	**U**	**1**
CO-5	Discuss about NMR, ESR and Mossbauer spectroscopy.	**U**	**1**

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

Name of the Course: Physical Chemistry V

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

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understanding of group theory and point groups.	**1,2/1**	**U**	**C**	**L**	
CO-2	Discuss about quantum mechanics and its applications.	**1,2/2**	**U**	**C**	**L**	

CO-3	Discuss about rotational and vibrational spectroscopy.	**1/1**	**U**	**C**	**L**	
CO-4	Discuss about Raman spectroscopy and electronic spectroscopy.	**1/1**	**U**	**C**	**L**	
CO-5	Discuss about NMR, ESR and Mossbauer spectroscopy.	**1/1**	**U**	**C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO 1	**PSO2**	**PSO3**	**PSO 4**	**PSO5**	**PO 1**	**PO 2**	**PO 3**	**PO4**	**PO5**
CO 1	2	-	-	-	-	2	1	-	-	-
CO 2	-	2	-	-	-	1	2	-	-	-
CO 3	2	-	1	-	-	1	-		-	-
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/ Discussion / Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics:

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

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSCPOC304**				
Course Title	Advanced Inorganic Chemistry				
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	Preliminary idea of spectroscopy and an understanding of analytical methods in chemistry				
Course Summary	Advanced Inorganic Chemistry is a comprehensive course designed to explore the fundamental principles and advanced topics in the field of inorganic chemistry. The course covers a wide range of topics including inorganic materials for industrial applications, electronic absorption spectroscopy, instrumental methods of analysis and some basic concepts of polymer nanotechnology.				

Detailed Syllabus:

Module	Unit	Content	Hrs	CO No.
I		**Inorganic Materials for Industrial Applications**	**12**	
	1	**Glass-**Glassy state and its properties, classification (silicate and non-silicate glasses).	02	1
	2	Manufacture and processing of glass.	02	1
	3	Composition and properties of the following types of glasses-Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.	03	1
	4	**Ceramics-** Brief introduction to types of ceramics. glazing of ceramics.	02	1
	5	**Cement**: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.	03	1
II		**Electronic absorption Spectroscopy**	**12**	
	6	Term symbols, energies of atomic and Molecular transitions,	02	2
	7	Electronic transitions,d-d transitions, selection rule for electronic transitions, electronic transitions in inorganic and organic molecules	03	2
	8	Nature of absorption spectra, nature of absorption spectra of transition metal complexes,	02	2
	9	Interpretation of electronic spectra of complexes- Orgel diagram and its applications	03	2
	10	Charge transfer spectra-charge transfer transitions in organic and inorganic molecules, LMCT and MLCT	02	2
III		**Instrumental Methods of Analysis-I**	**12**	
	11	Spectrophotometry- Laws of spectrophotometry,Beer Lambert's Law-Derivation and deviations	02	3

	12	Applications of spectrophotometry- colorimetry, atomic absorption spectroscopy and flame emission spectroscopy.	03	3
	13	Thermal methods- introductory aspects of TG, DTA and DSC,Instrumentation and applications.	03	3
	14	Nepheloturbidometry- Principle, instrumentation and applications	02	3
	15	Fluorimetry- Theory, Concepts of singlet, doublet and triplet electronic states, internal and external conversions, factors affecting fluorescence, quenching, instrumentation and applications	02	3
IV		**Instruments Methods of Analysis-II**	**12**	
	16	Chromatography: Classification of chromatographic methods, principles of differential migration, adsorption phenomenon, nature of adsorbents, solvent systems.	02	4
	17	Thin layer Chromatography (TLC): Preparation of plates, development of the chromatogram, Detection of the spots, factors effecting Rf values and applications,Advantages.	02	4
	18	Paper Chromatography: Principle, choice of paper and solvent systems, development of chromatogram – ascending, descending, radial and two dimensional chromatography and applications.	03	4
	19	Column Chromatography: Principle, Types of stationary phases, Column packing – Wet packing technique, Dry packing technique. Selection criteria of mobile phase (solvents) for eluting polar, non-polar compounds and its applications.	03	4
	20	Gas Chromatography: Theory and instrumentation (Block Diagram), Types of stationary phases and carrier gases (mobile phase).	02	4
V		**Polymer Nanotechnology**	**12**	
	21	Introduction to Polymer Nanotechnology,Importance and applications of polymer nanomaterials	02	5
	22	Nanomaterial synthesis- Solution based methods (sol-gel, emulsion polymerization), template assisted synthesis(nanoporous materials), self assembly techniques(micelles, vesicles,nanofibres)	03	5
	23	Characterzation of poymer nanomaterialsa- SEM,TEM, AFM,DLS, XRD Thermal analysis techniques-DSC,TGA	03	5
	24	Poymer Nanocomposites- Types of polymer nanocomposites (organic-inorganic, polymer- graphene, poymer-carbon nanotubes), properties and applications of polymer nanocomposites	02	5
	25	Applications of Polymer Nanotechnology-Biomedical Applications, Polymer Nanotechnology in Electronics, Energy Applications of Polymer Nanomaterials	02	5

References

1. Francesco Baino, Massimo Tomalino, Dilshat Tulyaganov, S, Ceramics, Glass and Glass-ceramic, Springer, 2021
2. Roman Pampuch, An introduction to Ceramics, Springer, 2014
3. Arun K Varshneya & John C Mauro, Fundamentals of Inorganic Glasses, Science Direct, 2019.

4. HFW Taylor, Cement Chemistry, ice publishing,1997
5. B K Sharma, Instrumental Methods of Chemical Analysis, Krishna Prakashan Media, 2011.
6. S.Prakash, G. D. Tuli, S.K Basu, R. D. Madan, Advanced Inorganic Chemistry, S Chand Pubishing, 2022
7. R. Gopalan, V. Ramalingam, Concise coordination chemistry, Vikas Publishing House, 2008
8. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry, Pearson, 2006
9. D. A. Skoog, F. James Holler. S.R. Crouch, Principles of Instrumental analysis, Cengage Learning, Noida, 2004
10. Joseph H. Koo, Nanocomposites: Processing, Characterization, and Applications, Mc Graw Hill, 2016
11. Joel R Fried, Polymer Science and Technology, Prentice Hall, 2014

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Learn the composition and applications of the different kinds of glass, Understand glazing of ceramics and the factors affecting their porosity, Get an awareness about the composition of cement and discuss the mechanism of setting of cement.	**R, U**	**1**
CO-2	Understanding of Electronic Transitions, Interpretation of Spectra, Insight into Molecular Structure and Dynamics	**U, Ap**	**2**
CO-3	Interpret the theoretical principles of selected instrumental methods with spectrophotometric methods, Understanding of Analytical Techniques	**R, U, An**	**1**
CO-4	Understanding of Chromatographic Principles, learn to design and optimize chromatographic experiments, Understand various separation techniques and choose the most appropriate analytical technique for a variety of samples.	**U, An**	**1**
CO-5	A comprehensive understanding of the principles of polymer chemistry and nanotechnology, introduction of characterization techniques for analyzing the	**R, U, Ap**	**5**

	structure and properties of polymer nanocomposites, explore the applications of polymer nanotechnology in areas such as medicine, electronics, and energy.		

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

Name of the Course: Advanced Inorganic Chemistry

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

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Learn the composition and applications of the different kinds of glass, Understand glazing of ceramics and the factors affecting their porosity, Get an awareness about the composition of cement and discuss the mechanism of setting of cement.	**1/1**	**R, U**	**F**	**L**	
CO-2	Understanding of Electronic Transitions,Interpretation of Spectra,Insight into Molecular Structure and Dynamics	**2/2**	**U, Ap**	**F, C**	**L**	
CO-3	Interpret the theoretical principles of selected instrumental methods with spectrophotome	**1/1**	**R, U, An**	**F, P**	**L**	

	tric methods, Understanding of Analytical Techniques					
CO-4	Understanding of Chromatographic Principles, learn to design and optimize chromatographic experiments , Understand various separation techniques and choose the most appropriate analytical technique for a variety of samples.	**1/1**	**U, An**	**F, P**	**L**	
CO-5	A comprehensive understanding of the principles of polymer chemistry and nanotechnology, introduction of characterization techniques for analyzing the structure and properties of polymer nanocomposites, explore the applications of polymer nanotechnology in areas such as medicine, electronics, and energy.	**1/5**	**R, U, Ap**	**F, C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO 1	PSO2	PSO5	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	3	-	-	-	-	-
CO 2	-	2	-	-	2	-	-	-	-
CO 3	3	-	-	3	-	-	-	-	-
CO 4	3	-	-	3	-	-	-	-	-
CO 5	-	-	2	3	-	-	-	-	-

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ 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	✓	✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSCPOC305**				
Course Title	Organic Spectroscopy				
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	Understanding of organic chemistry, including concepts such as molecular structure, bonding, functional groups, and spectroscopic techniques and basic understanding of principles of spectroscopy				
Course Summary	Provides students with a deep understanding of spectroscopic techniques and their applications in chemical analysis, and various scientific disciplines. Students gain knowledge for interpreting spectral data, and applying spectroscopic methods to solve problems in chemistry and related fields				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Electronic spectroscopy**	**12**
	1	Types of electronic transitions. The absorption laws and measurement of absorption intensity, Important useful terms concerning ultraviolet spectroscopy-chromophores and auxochromes, Bathochromic shift and hypsochromic shift, factors influencing the positions and intensity of absorption bands	4
	2	Woodward - Fieser rules and its applications-absorption spectra of dienes, polyenes and unsaturated carbonyl compounds, aromatic compounds	6
	4	Instrumentation of UV-visible spectrophotometer	2
II		**IR spectroscopy**	**12**
		Vibrational frequencies and factors affecting them -identification of functional groups - functional group region- finger print region - far IR region.	4
		Intra and intermolecular factors affecting the carbonyl frequency, Characteristic absorption frequencies of various carbonyl compounds, amides, amines.	4
		Applications of IR spectroscopy- identification of an organic compounds, detection of impurities, detection of functional groups, distinction between inter and intramolecular hydrogen bonding (effect of dilution) and cis-trans isomerism in organic chemistry	4
III		**Mass spectroscopy**	**12**
	9	Principles - measurement techniques - (El, Cl, FD and FAB) -	3
	10	Presentation of spectral data - molecular ions - isotope ions - fragment ions of odd and even electron types - rearrangement ions - factors affecting cleavage patterns - simple and multicentre fragmentation – Mc Lafferty	4

		rearrangement - Mass spectra of hydrocarbons, alcohols, phenols, aldehydes and ketones.	
	11	GC-MS and LC-MS-applications	3
	12	Important applications of mass spectroscopy-structure determination, molecular weight (propane, ethyl acetate, benzene, toluene)	2
IV		**NMR spectroscopy I**	**12**
	18	Nuclear spin - magnetic moment of a nucleus – nuclear energy levels in the presence of magnetic field - basic principles of NMR experiments - CW and FT NMR.	4
	19	^{1}H NMR -Chemical shift, chemical shift parameters and internal standards, factors affecting the chemical shifts- shielding and deshielding, anisotropic effect, effect of hydrogen bonding	4
	20	Spin-spin coupling, geminal and vicinal coupling constants, relaxation process, lanthanide shift reagents, ^{1}H NMR spectra of simple organic molecules (ethanol, 1-chloro propane, ethyl acetate, benzene), applications of ^{1}NMR	4
V		**NMR spectroscopy II**	**12**
		^{13}C NMR - introduction, comparison of ^{13}C and ^{1}H-NMR spectroscopy, chemical shift, factors affecting the chemical shifts	5
		Proton decoupling and Off resonance decoupling, ^{13}C NMR spectra of simple organic molecules (ethyl acetate, toluene)	4
		introduction to 2D NMR, MRI, introduction to solid state NMR spectroscopy (basic idea only)	3

References

1. Kemp, W. Organic Spectroscop,3rd Edn., Macmillan Publishers Limited, London, 1991
2. Williams, D. H. and Flemming, I. "Spectroscopic Methods in Organic Chemistry", 5th Edn., McGraw Hill. USA, 2011.
3. P. S. Kalsi, Spectroscopy of organic compounds, 8th Edn., New Age International Publishers, 2020.
4. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, Introduction to Spectroscopy, 5th Edn., Brooks/Cole, 2014.
5. David J. Kiemle, David L. Bryce, Francis X. Webster, Robert M. Silverstein, Spectrometric identification of organic compounds, Wiley, 6th Edn, 2014

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding different types of electronic transitions and their relevance in molecular absorption,	**R, U**	**1,2**

	Proficiency in applying Woodward - Fieser rules for predicting absorption spectra		
CO-2	Understanding vibrational frequencies and their dependence on molecular structure and bonding, Proficiency in identifying functional groups based on characteristic absorption frequencies	**R, U**	**1,2**
CO-3	Understanding the principles and measurement techniques of mass spectrometry, including various ionization methods, Ability to interpret mass spectra, including molecular ions, fragment ions, and rearrangement ions	**R, U**	**1,2**
CO-4	Understanding nuclear spin, energy levels, and the basic principles of NMR experiments, including continuous wave (CW) and Fourier transform (FT) NMR	**R, U**	**1,2**
CO-5	Proficiency in interpreting 1H NMR and 13C NMR spectra, including chemical shift, spin-spin coupling, and relaxation processes, Ability to apply NMR spectroscopy for structural elucidation and characterization of organic molecules, including the use of 2D NMR techniques	**R, U, Ap**	**1,2**

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

Name of the Course: Organic Spectroscopy

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

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Understanding different types of electronic transitions and their relevance in molecular absorption, Proficiency in applying	**1,2/1,2**	**R, U**	**C**	**L**	

	Woodward - Fieser rules for predicting absorption spectra					
2	Understanding vibrational frequencies and their dependence on molecular structure and bonding, Proficiency in identifying functional groups based on characteristic absorption frequencies	**1,2/1,2**	**R, U**	**C**	**L**	
3	Understanding the principles and measurement techniques of mass spectrometry, including various ionization methods, Ability to interpret mass spectra, including molecular ions, fragment ions, and rearrangement ions	**1,2/1,2**	**R, U**	**C**	**L**	
4	Understanding nuclear spin,	**1,2/1,2**	**R, U**	**C**	**L**	

	energy levels, and the basic principles of NMR experiments, including continuous wave (CW) and Fourier transform (FT) NMR					
5	Proficiency in interpreting 1H NMR and 13C NMR spectra, including chemical shift, spin-spin coupling, and relaxation processes, Ability to apply NMR spectroscopy for structural elucidation and characterization of organic molecules, including the use of 2D NMR techniques	**1,2/1,2**	**R, U, Ap**	**C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	-	-	-	-	2	2	-	-	-	-
CO2	2	2	-	-	-	-	2	2	-	-	-	-

CO 3	2	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	✓	✓		✓

Discipline	POLYMER CHEMISTRY
Course Code	**UK6DSCPOC306**
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	3 hours	-	2 hours	5

Pre-requisites	Reactions of common organic compound and introduction of reaction mechanism.
Course Summary	This course provides understanding in properties and structure of carbohydrates, oils, fats, alkaloids, vitamins, proteins, nucleic acids, organic sulphur compounds, nitrogen compounds, hydrogels. It also provide skill in organic preparations and analysis.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Carbohydrates**	**9**
	1	Classification and Nomenclature of monosaccharides. Configuration of monosaccharides.	1
	2	Preparation, properties and structural elucidation of glucose, fructose and sucrose. Anomers, epimers and mutarotation.	2
	3	Mechanisms of Epimerization and Mutarotation, Ascent and descent series in aldoses and ketoses. Conversion of aldoses to ketoses and ketoses to aldoses. Conversion of glucose to mannose. Polysaccharides:	3
	4	Starch and Cellulose - Preparation, properties and structure of starch and cellulose	3
II		**Oils, Fats, Alkaloids, Vitamins**	**9**
	5	Oils and Fats: - Occurrence and extraction. Common fatty acids, soap, saponification value, iodine value, acid value.	1
	6	Alkaloids: - Introduction, Extraction and structural elucidation of conine, nicotine and importance of quinine, morphine and codeine.	3
	7	Terpenes: - Introduction - Isoprene and special isoprene rules. Isolation of terpenoids. Essential oils, isolation of citral and geraniol- structural elucidation.	3
	8	Vitamins: - Classification and structure (structures of vitamin A, B1 and C-structural elucidation). Chemistry of vision.	2
III		**Amino acids, Proteins and Nucleic acids**	**9**
	9	Amino acids: - Classification, structure and stereochemistry of amino acids, general methods of preparation and reactions of a - amino acids, essential and non-essential amino acids, zwitter ion, isoelectric point.	3

	10	Peptides: structure and synthesis (Carbobenzoxy method, Sheehan method only, Solid Phase Peptide Synthesis).	3
	11	Proteins: - Structure of proteins, denaturation and colour reactions. Nucleic acids: - Classification and structure of DNA and RNA.	3
IV	**Organic Sulphur and Nitrogen compounds**		**9**
	12	Aromatic sulfur compounds-Preparation and applications of benzene sulphonic acids, toluene sulphonic acid, benzene sulphonyl chloride, sulphanilic acid, sulphanilamide and sulpha drugs- sulphapyridine, sulphathiazole, sulphadiazine, sulphaguanidine and sulphaacetamide. synthetic detergents and detergent action, alkyl and aryl sulphonate.	3
	13	Organic Nitrogen Compounds Nitro compounds- preparation of nitroalkanes and nitroarenes, tautomerism, reduction of nitrobenzene in acid, base and neutral medium.	2
	14	General methods of preparation and reactions of aliphatic and aromatic amines, Sandmeyer's reaction classification of amines.	1
	15	Separation of mixture of amines, methods to distinguish primary, secondary and tertiary amines, basicity of amines, effect of substituents.	2
	16	Quarternary ammonium compounds- Hofmann elimination. Diazonium and diazo compounds preparation, structure and their synthetic importance.	1
V	**Bio-polymers and Hydrogels**		**9**
	17	Structural characteristics and sources of bio-polymers such as cotton, wool, silk, collagen, hyaluronic acid, melanin, and lignin. Bio-polymers and discuss their importance in biological systems, highlighting their functions in living organisms.	3
	18	Role of bio-polymers in structural support, information storage (nucleic acids), enzymatic activity (proteins), and biological signalling.	1
	19	Monomers and polymers obtained from renewable materials such as castor oil (polyamide-11), natural gums (polysaccharides), oleochemicals (bio-based surfactants), cashew nut shell liquid (cardanol-based polymers), carbohydrate-derived monomers (polysaccharide derivatives), and furfural (furan-based polymers) as a raw material for monomers and polymers. Importance of structural integrity and conformational changes in enzymatic activity and biological processes.	3
	20	Hydrogels- classification, properties, characterization and their importance in drug delivery and environmental applications.	2

Organic Chemistry-IV Practical   30Hrs

Unit	Contents	Hrs
1	Reactions of carbohydrates, aromatic nitro compounds, aromatic amino compounds	**10**
2	Test to distinguish	**5**

	a. Reducing and Non reducing sugars b. Primary, secondary and tertiary amines. c.Monoamides and diamides	
3	Preparation of organic compounds i.Halogination-Bromination of acetanilide ii.Nitration of acetanilide iii.Acetylation of Aniline iv. Benzoylation of aniline	**15**

References

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8. Rastogi, Biochemistry, Tata Mc Graw –Hill Publication ,1996.
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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 structure of glucose, fructose, sucrose, starch and cellulose.	**U**	**1**
CO-2	Describe the isolation and structure of terpene , alkaloids and vitamins.	**R, U**	**3**
CO-3	Synthesis and classify amino acids, proteins, nucleic acids.	**An**	**1,2**

CO-4	Describe the preparation and Chemistry of Nitrogen and sulphur compounds.	**Ap**	**1**
CO-5	Understanding the structural characteristics, sources, and roles of bio-polymers in biological systems, enzymatic activities, and applications.	**E**	**6**
CO-6	Understanding and executing reactions involving carbohydrates, aromatic nitro compounds, aromatic amino compounds, as well as the preparation of organic compounds through halogenation, nitration, acetylation, and benzoylation processes.	**U,Ap**	**4**

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

Name of the Course: Organic Chemistry IV

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

CO No.	**Course outcome**	**PO/ PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/ Tutorial (T)**	**Practical (P)**
CO-1	Explain the structure of glucose, fructose, sucrose, starch and cellulose.	**1/ 1**	**U**	**F, C**	**L**	
CO-2	Describe the isolation and structure of terpene, alkaloids and vitamins.	**3/3**	**R, U**	**P**	**L**	
CO-3	Synthesis and classify amino acids, proteins, nucleic acids.	**1/1,2**	**An**	**C**	**L**	
CO-4	Describe the preparation and Chemistry of Nitrogen and sulphur compounds.	**2/1**	**Ap**	**F**	**L**	
CO-5	Understanding the structural characteristics, sources, and roles of bio-polymers in biological systems, enzymatic activities, and applications.	**1/ 6**	**E**	**F**	**L**	
CO-6	Understanding and executing reactions involving carbohydrates, aromatic nitro compounds, aromatic amino compounds, as well as the	**6/4**	**U,Ap**	**C,P**		**P**

	preparation of organic compounds through halogenation, nitration, acetylation, and benzoylation processes.					

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

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 6	PO1	PO2	PO3	PO6
CO 1	2	-	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	1	-
CO 3	2	-	2	-	-	3	-	-	-
CO 4	3	-	-	-	-	-	2	-	-
CO 5	-	-	-	-	2	1	-	-	-
CO 6	-	-	-	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
- Project Evaluation
- 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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSEPOC301**				
Course Title	Polymers in Industry				
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	Knowledge of specific polymer properties and their corresponding applications Understanding the characteristics of thermoplastics, thermosets, elastomers and specialty polymers, as well as their uses in various industries				
Course Summary	"Polymers in Industry" connects the various polymers of natural and synthetic origins to their wide-range applications in the society. It includes the industrial polymers for use as fibers for textiles, adhesives for use as advanced bonding agents, for use as films for food packaging, biomedical polymers and high-performance polymers for space applications. The course also helps the students to acquire necessary skills of polymer synthesis, identification and characterizations.				

Detailed Syllabus:

Module	Unit	Content	HRS
I		**Polymers in fiber industry**	**9**
	1	Plants and plant parts for the production of natural fibers, conditions to promote growth and yield. harvesting, extraction, processing, and characteristics of natural fibers (cotton, wool, silk, jute, flax). Advantages of natural fibers over synthetic fibers.	1
	2	Applications of natural fibers in textiles, other important applications. Regenerated cellulose fibers-viscose, tencel, cellulose acetate and triacetate (Mention only).	2
	3	Applications of synthetic fibers: Polyester, nylon, acrylic, polypropylene, polyethylene, acetate, Lycra and their manufacturing processes. Properties and advantages of synthetic fibers.	2
	4	In depth comparison of synthetic and natural fibers in terms of molecular structure, physical and chemical properties, and applications. Environmental friendliness of natural fibers and environmental concerns of synthetic fibers, strategies of sustainable and responsible approaches.	2
	5	Other fiber forming materials - glass, ceramic, carbon and metal, Innovations in fiber technology. Novel developments in textile fibers and textile chemistry and technology.	2
II		**Polymers in adhesives coating**	**9**
	6	Polymers in Adhesives-tack and adhesion, adhesive bonding, classification of adhesives theories of adhesion, wettability and	1

		contact angle, adhesive strength, preparation of common adhesives for use	
	7	Performance of adhesives - shear, peel and cleavage properties, factors affecting adhesive performance and durability.	2
	8	Surface preparation and design of adhesive joints, selection of adhesives for various applications.	2
	9	Anaerobic adhesives, advantages and disadvantages, cyanoacrylates, hot melt adhesive, pressure sensitive adhesives, silicone adhesives, water based adhesives, inorganic adhesives. types - epoxy, urethane, acrylic, phenolic and high temperature hot melt adhesives and PVC plastisol types, adhesives for advanced applications.	1
	10	Surface preparation for application of paints, primers, Paint properties and their evaluation, mechanism of film formation, factors affecting coating, methods used for film coating and characterization of coatings.	2
	11	Carrier properties, optical properties, ageing properties, rheological properties and adhesion properties of coatings.	1
III		**Packaging Applications**	**9**
	12	Polymers for food packaging, requirements, conventional/biobased food packaging materials, Edible film and coatings.	2
	13	Polysaccharide based coatings, Lipid based coatings, Protein based coating, First, Second and Third biobased packaging materials.	2
	14	One way/two way permeability of thermoplastic polymers, Multilayer films, Processing, packing for feel good factors, intelligent packing and logistics.	2
	15	Physical changes, biological changes, and chemical changes and chemical reactions in packed foods, shelf life of foods, Factors controlling shelf life. Deteriorative reaction in foods, Enzyme reactions, Inert atmosphere for food packing.	2
	16	Packaging of dairy products, Packaging of cereals, Packaging of other foods and confectionary	1
IV		**Polymers in Biomedical application**	**9**
	17	Biomedical Polymers, classification, criteria for the selection of Biomedical Polymers	1
	18	Polymers in dentistry and bone repairs, properties, applications and new developments	2
	19	Polymers in Tissue adhesives and Dialysis Membrane, properties, applications and new developments	2
	20	Polymers in Blood oxygenators, Bone cement, Prostheses, properties, applications and new developments	2
	21	Polymers in Biodegradable sutures, Control drug delivery systems, properties, applications and new developments, polymers of natural origin and synthetic origin for Biodegradable sutures	2
V		**Polymers in Aerospace application**	**9**

	22	Special polymers for space applications, structural and property requirements, thermal, mechanical, electrical, magnetic and optical properties.	3
	23	Polymers in aerospace applications: protective covering, Space Suits, structural and thermal applications, high strength transparent windows	2
	24	Polymers in aerospace applications: Electronic applications	2
	25	Polymers in aerospace applications: High performance adhesives	2

Polymers in Industry Practical 30 hrs

Module	Unit	Content	Hrs
I		**Polymer analysis and preparation**	**30**
	1	Preparation of synthetic thermoplastic polymers (PS, PMMA) and biopolymers (Chitosan, etc)	
	2	Preparation of conducting polymer s (Polyaniline, Polypyrrole)	
	3	Preparation of thermosetting plastics (PF, MF) and condensation polymers (Nylon 66)	
	4	Preparation of adhesives (water based and solvent based)	
	5	Determination of viscosity average molecular weight of polymer (PVA, Chitosan etc.)	
	6	Qualitative Analysis of selected elastomers (Nitrile rubber, Polychloroprene, crosslinked Natural rubber), plastics (PVC) and fibers (PAN fiber)	
	7	Determination of DRC and TSC of latex	
	8	Determination of density of polymers	
	9	Ash content analysis of plastics	
	10	Determine the glass and filler content	

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2. Menachem Lewin, “Handbook of Fiber Chemistry”, 3rd Edition, CRC Press 2006.
3. Gerald L. Schnberger, “Adhesives in manufacturing”, Marcel Dekker Inc., New York, e book-2018.
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7. David A. Klein Determination of viscosity average molecular weight of polymer: Title: "Polymer Chemistry: Principles and Practice" CRC Press Edition: Second Edition ISBN: 978-1138403630
8. Ash content analysis of plastics: ASTM D2584, ASTM D5630
9. Water Absorption test of polymers ASTM C272, ASTM D570
10. Determine the glass and filler content: ISO 1172:1996

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	After going through this module, students will gain insight into the fiber producing plants, their harvest and production of fibers. Students will also make a comparative study of natural and synthetics fibers highlighting the advantages and disadvantages with a focus on their unique properties.	**R, U, An**	**8**
CO-2	After going through this module, students will become familiar with the field of adhesives, the chemistry behind adhesives and adhesive coating, action and durability. Students will be able to effectively classify existing adhesives and apply the classification strategies to a new adhesive based on its properties, performance and durability. Students will also develop a comprehensive understanding of pigments and paints and other additives for use in adhesives.	**R, U, An, E**	**5**
CO-3	This module will help the students to develop a comprehensive understanding of food packaging materials, including conventional materials and novel intelligent packing materials for food stuff. They will learn the physical chemical and biological changes that happen to the packed food and will be able to predict the shelf life of foods and apply this for application in the food packing industry for the benefit of the society.	**U, Ap, An, E**	**6**
CO-4	From this module, students will develop a thorough understanding of polymers used in biomedical applications, including their chemical structures, properties, and biocompatibility. Students will be able to select different types of polymers for unique biomedical applications.	**U, Ap, An, E**	**8**
CO-5	Students will develop a thorough understanding of the criterion requirements of different polymers for aerospace applications. The focus will be on thermal, mechanical, electrical, magnetic and optical properties.	**R, U, Ap**	**1**
CO-6	After carrying out the experiments in this module, students will be able to prepare and characterize common polymers for use in the society in a qualitative way. Also, the students will be able to determine the quality of certain polymers and compare this with other polymer samples of similar or different structure and properties	**U, A, An, E**	**4**

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

Name of the Course: Polymers in Industry

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

CO No.	Course Outcomes	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	After going through this module, students will gain insight into the fiber producing plants, their harvest and production of fibers. Students will also make a comparative study of natural and synthetics fibers highlighting the advantages and disadvantages with a focus on their unique properties.	**1/8**	**R, U, An**	**F, P**	**L**	
CO-2	After going through this module, students will become familiar with the field of adhesives, the chemistry behind adhesives and adhesive coating, action and durability. Students will be able to effectively classify existing adhesives and apply the classification strategies to a new adhesive based on its properties, performance and durability. Students will also develop a comprehensive understanding of pigments and paints and other additives for use in adhesives.	**4/5**	**R, U, An, E**	**F, M**	**L**	
CO-3	This module will help the students to develop a comprehensive understanding of food packaging materials, including conventional materials and novel intelligent packing materials for food stuff. They will learn the physical chemical and biological changes that happen to the packed food and will be able to predict the shelf life of foods and apply this for application in the food packing industry for the benefit of the society.	**7/6**	**U, Ap, An, E**	**F, C**	**L**	
CO-4	From this module, students will develop a thorough understanding of polymers used in biomedical applications, including their chemical structures, properties, and biocompatibility. Students will be able to select different types of polymers for unique biomedical applications.	**1/8**	**U, Ap, An, E**	**C**	**L**	

CO-5	Students will develop a thorough understanding of the criterion requirements of different polymers for aerospace applications. The focus will be on thermal, mechanical, electrical, magnetic and optical properties.	**2/1**	**R, U, Ap**	**M**	**L**	
CO-6	After carrying out the experiments in this module, students will be able to prepare and characterize common polymers for use in the society in a qualitative way. Also, the students will be able to determine the quality of certain polymers and compare this with other polymer samples of similar or different structure and properties	**3,4/4**	**U, A, An, E**	**p**		**p**

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

Mapping of COs with PSOs and POs :

	PSO -1	**PSO-4**	**PSO-5**	**PSO -6**	**PSO -8**	**PO -1**	**PO -2**	**PO -3**	**PO -4**	**PO-7**
CO 1		-	-		3	2				
CO 2		-	3	-					3	
CO 3			-	2	-					2
CO 4		-	-		2	3				
CO 5	3	-		-	-		2			
CO 6		3						3	2	

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Assignment/ 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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSEPOC302**				
Course Title	Advanced Polymeric Materials				
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	Multidisciplinary knowledge such as nanotechnology, material science, bioengineering and chemistry				
Course Summary	This elective course aims to provide students with a comprehensive understanding advanced polymeric materials such as polymer composites, blends, alloys and bio hybrid polymeric materials, including their classification. Students will gain insight regarding the thermodynamics of mixing of polymer components, their interactions leading to miscibility and compatibility. Students will gain knowledge of the methods to prepare such potential materials for the society, principles underlying their properties and product manufacturing in industrial sector.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Polymer Composites**	**12**
	1	Introduction to polymer composites, definitions, criteria for matrix polymer and inclusions, classification-particulate, fiber (short & long) and filler composites and laminates, applications	3
	2	Polymer microcomposites and nanocomposites, comparison of preparation methods and properties, biocomposites,	3
	3	Role of polymer matrix and inclusions (fiber/filler) in forming a good interface and improving composite properties, chemistry of reinforcement and property enhancement, effective/ineffective utilization of filler/fiber surface by polymer chains	3
	4	Techniques of polymer composite preparation, such as hand layup technique, filament winding technique, spray-up technique, and pultrusion	3
II		**Polymer blends and Alloys**	**12**
	5	Introduction to polymer blends and alloys, definitions, criteria for component polymers for blend formation, classification of polymer blends and alloys with examples	2
	6	Interactions between polymer components in blend, chemistry of compatibility and miscibility, methods to assess compatibility and miscibility	2
	7	Thermodynamics of polymer-polymer mixing, blend morphology and characterization methods	3

	8	Preparation of polymer blends and alloys, product manufacture and characterization methods	2
	9	Polymer blends and alloys of commercial importance, methods to match their properties for end use	3
III		**Polymer Nanocomposites and Nano fillers**	**12**
	10	Polymer nanocomposites-Introduction, uniqueness, Mechanical, thermal, electrical and optical properties of importance	3
	11	Synthetic methods for various polymer nanocomposite materials: sputtering, mechanical alloying, sol-gel synthesis, thermal spray synthesis	3
	12	Polymer nanocomposites based on fullerenes, graphene, clay carbon nanotubes and other nanomaterials.	2
	13	Ceramic-Metal Nanocomposites, Ceramic based nanoporous composite, Metal matrix nanocomposites	2
	14	Natural nano-biocomposites and Biomimetic nanocomposites	2
IV		**Bio hybrid Polymeric Materials**	**12**
	15	Introduction to Biohybrid Polymeric Materials, biomolecule-polymer interactions	4
	16	Fabrication techniques-Micro- and nanofabrication techniques	4
	17	Design of biofunctional materials for various applications such as drug delivery, tissue engineering, biosensing, and biocatalysis	4
V		**Need Analysis and Novel Product Development**	**12**
	18	Need analysis for novel materials, research methodology, innovation and programmed thinking, improving skills.	3
	19	Market study, startups, entrepreneurship costing and marketing of the products, product design and diversification, profit concept	3
	20	Financial support from various agencies – setting up of industry, writing of project proposals and reports	3
	21	Government regulations and rules, Environmental Rules, Sustainability and responsibility, Green Practices in Industry	3

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6. David W. Grainger and Catherine Picart, Biohybrid Materials: Synthesis, Characterization and Applications, Wiley publishers, 2019.

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8. Abha Mathur, Entrepreneurship Development, 1st Edition, Taxmann Publications, 2021
9. 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	Upon completion of the module, the student will understand polymer composites, nanocomposites, and biocomposites with emphasis of the role of polymer matrix and inclusions in deciding composite properties, reinforcing mechanism and its chemistry	**R, U**	**1**
CO-2	After going through this module, the student will understand polymer blends and alloys, their preparation and characterization methods and applications of the products. Student will gain insight regarding the miscibility and compatibility and the chemical interactions responsible for this. Further look in to the thermodynamics of polymer-polymer mixing also will help the students to predict possible interactions in other blends and alloys.	**U, Ap, An**	**5**
CO-3	Student will understand polymer nanocomposites, their preparation and characterization methods. Student will get knowledge of the important properties properties and various nanomaterials of synthetic and natural origin.	**U**	**1**
CO-4	Students will learn on biohybrid polymeric materials, their characterization techniques and micro- and nanofabrication techniques. Students will identify the design of biofunctional materials for various applications	**U, An, E**	**5**
CO-5	Students will gain idea regarding the need analysis, research methodologies, product development and marketing. Students will get knowledge of startups, entrepreneurships and skill to think in a novel way to develop project proposals for funding, effectively execute the ideas and make final reports	**U, Ap, An, E, C**	**6**
CO-6	Develop a comprehensive project report and identify various financial support schemes for entrepreneurship in the industry	**E**	**4**

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

Name of the Course: Advanced Polymeric Materials
Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	Course Outcomes	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Upon completion of the module, the student will understand polymer composites, nanocomposites, and biocomposites with emphasis of the role of polymer matrix and inclusions in deciding composite properties, reinforcing mechanism and its chemistry	**1/1**	**R, U**	**F, C**	**L**	
CO-2	After going through this module, the student will understand polymer blends and alloys, their preparation and characterization methods and applications of the products. Student will gain insight regarding the miscibility and compatibility and the chemical interactions responsible for this. Further look in to the thermodynamics of polymer-polymer mixing also will help the students to predict possible interactions in other blends and alloys.	**2/5**	**U, Ap, An**	**C**	**L**	
CO-3	Student will understand polymer nanocomposites, their preparation and characterization methods. Student will get knowledge of the important properties properties and various nanomaterials of synthetic and natural origin.	**1/1**	**U**	**C**	**L**	
CO-4	Students will learn on biohybrid polymeric materials, their characterization techniques and micro- and nanofabrication techniques. Students will identify the design of biofunctional materials for various applications	**4/5**	**U,An, E**	**F,C**	**L**	
CO-5	Students will gain idea regarding the need analysis, research methodologies, product development and marketing. Students will get knowledge of startups, entrepreneurships and skill to think in a novel way to develop project proposals for funding, effectively execute the ideas and make final reports	**1/ 6**	**U, Ap, An, E, C**	**C**	**L**	
CO-6	Student can develop a comprehensive project report and identify various financial	**8/4**	**E**	**P**	**L**	

	support schemes for entrepreneurship in the industry					

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

Mapping of COs with PSOs and POs :

	PSO-1	PSO-4	PSO -5	PSO-6	PO-1	PO-2	PO-4	PO-8
CO 1	2	-	-	-	2			
CO 2	-	-	3			2		
CO 3	2	-	-		3			
CO 4	-	-	3				2	
CO 5	-		-	3	2			
CO 6	-	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	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSEPOC303**				
Course Title	Automobile Applications of Polymers				
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	Basic knowledge in Automobile part and the application of Automobile parts				
Course Summary	To learn about the various automotive components and materials. To learn the polymers in the interior and exterior of the vehicle, rubber products used in automobiles				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Automotive Components and Materials**		**12**
	1	History of automobile industry, need for polymers	3
	2	Advantages and limitations of polymers	3
	3	Competition between plastics, composites and other materials, processing, designing with plastics	3
	4	Selection criteria of material.	3
II	**Polymers in the Interior of the Vehicle**		**12**
	5	Interiors, dominance of polymeric components, Fashion and function	3
	6	Plastics surfaces (Texture and fogging),	3
	7	Plastic structure and panel application (Sandwich concept, Instrumental panel, other sensitive panels),	3
	8	Structural and mechanical components (Seating, Door and window furniture, steering wheel, airbags, seat belts, pedals, instrumental and others).	3
III	**Polymers in the Exterior of the Vehicle**		**12**
	9	Exteriors: Body panels and structure – Painting problems –	3
	10	Bumpers – Other exteriors: Grills, Spoilers, Mirrors,	3
	11	Door handles, Wheel trim, Road wheels,	3
	12	Sun roof components, Windscreen wiper assemblies.	3
IV	**Engine, Powertrain and Chassis**		**12**
	13	The engine compartment, cooling system under bonnet structure	3
	14	Transmission, engine hang on parts,	3
	15	Engine interior, composite engine, suspension, steering, brakes, fuel tanks	3
	16	Electrics: battery boxes, circuitry, lighting and	3

		instrumentation, electronics.	
V		**Rubber Products Used**	**12**
	17	Rubber mounts	3
	18	Spring, Seals,	3
	19	O-ring, rubber to metal bonding components	3
	20	Coupling hoses, brake lining, disc brakes.	3

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10. Davies, G., Materials for Automobile Bodies, Butterworth-Heinemann Publications, 2003.
11. Koronis, G. Silva, A., Green Composites for Automotive Applications, Woodhead Publishing Series in Composites Science and Engineering, 2018.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the knowledge about requirements of automobile industry	**U, R**	**1**
CO-2	Apply the polymeric (plastic) components in automobile interior parts.	**Ap, U**	**5**
CO-3	Apply the polymeric (plastic) components in automobile exterior parts.	**Ap, U**	**6**

CO-4	To learn about polymeric materials significance in automobiles structural and mechanical components.	**U**	**6**
CO-5	Determine the rubber components used in automobile parts.	**R, U**	**5**

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

Name of the Course: Automobile Applications of Polymers
Credits: 4:0:0 (Lecture: Tutorial:Practical)

CO No.	Course Outcomes	PO / PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain the knowledge about requirements of automobile industry.	**4/1**	**U, R**	**F, C**	**L**	
CO-2	Apply the polymeric (plastic) components in automobile interior parts.	**7/5**	**Ap, U**	**M**	**L**	
CO-3	Apply the polymeric (plastic) components in automobile exterior parts.	**3/6**	**Ap, U**	**M**	**L**	
CO-4	To learn about polymeric materials significance in automobiles structural and mechanical components.	**5/6**	**U**	**F, C**	**L**	
CO-5	Determine the rubber components used in automobile parts.	**5/5**	**R, U**	**F, C**	**L**	

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

Mapping of COs with PSOs and POs :

	PSO-1	PSO-5	PSO-6	PO-3	PO-4	PO-5	PO-7
CO 1	2		-		3	-	-
CO 2		2	-		-	-	2
CO 3		-	3	2	-	-	-
CO 4	-	-	2			2	
CO 5	-	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		✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6DSEPOC304**				
Course Title	Characterization Techniques for Polymers				
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
	3	3 hours	-	2 hours	5
Pre-requisites	Knowledge on different techniques for molecular analysis.				
Course Summary	This course focuses on advanced analytical techniques used for the characterization of polymers. It provides a comprehensive understanding of cutting-edge methods for analyzing polymer structure, properties, and behavior at the molecular level. Emphasis is placed on advanced spectroscopic, chromatographic, imaging, and computational techniques, along with their applications in polymer science and engineering. It includes of different spectral methods for polymer characterization in laboratory.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Chromatography Techniques**	**9**
	1	Introduction to chromatographic methods: thin layer chromatography, column and gas chromatography.	2
	2	Principles, instrumentation and application of Gas liquid Chromatography	2
	3	Principles, instrumentation and application of High Performance Liquid Chromatography	2
	4	Principles, instrumentation and application of gel permeation chromatography (GPC) including brief about column, detectors and stationary phases and their significance	3
II		**Spectroscopic Techniques**	**9**
	5	Principles, instrumentation, and applications for structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) using FT-IR, electron spin resonance, Raman, nuclear magnetic resonance (^{1}H NMR, ^{13}C NMR).	4
	6	Mass Spectroscopy: Introduction, basic principles, instrumentation, fragmentation patterns, and interpretation of mass spectra and applications. Basis and application of MALDI-TOF, andESI-MS in characterisation of different polymers including biopolymer for determination of molecular mass and structures (branching, and chain length)	5
III		**Microscopic and X-ray Techniques**	**9**
	7	Optical microscopy,	1
	8	Principles, instrumentation, and applications of SEM in polymer characterization	2
	9	Principles, instrumentation, and applications of TEM in polymer	2

		characterization	
	10	Principles, instrumentation, and applications of AFM in polymer characterization	2
	11	XRD: basics principle andapplications in polymers characterization,	1
	12	Contact angle and measurement	1
IV	**Thermal and Mechanical Characterizations**		**0**
	13	Principle and applications of Thermal gravimetric analysis (TGA) in polymer analysis	3
	14	Principle and applications of Differential thermal analysis (DTA) in polymer analysis	2
	15	Principle and applications of Differential scanning calorimeter (DSC) in polymer analysis	2
	16	Dynamic mechanical analyser (DMA) and thermal mechanical analyser (TMA) in polymer analysis	2
V	**Molecular Weight determination**		**9**
	17	Different methods used for determination of molecular mass	5
	18	Particle size analyser, Measurement and importance of zeta potential, Instrumentation	4

Characterization Techniques for Polymers Practical 30 Hrs

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Polymer analysis and preparation**		30
	1	To identify the functional groups and components in various polymers (homo and copolymers) using FTIR.	
	2	To separate and identify additives in a given polymeric sample by thin layerchromatography	
	3	Evaluate percentage crystallinity and size of polymeric samples by XRD curve.	
	4	To separate and identify the polymeric samples and mixture by TLC.	
	5	To analyze film morphology (homogeneity, distribution and size) by opticalmicroscope.	
	6	To determine the size of polymer/additives particles by particle size analyzer.	
	7	Characterization of FillerContent /Ash Content of common polymers by Thermogravimetric Analysis, (TGA).	
	8	Identification of additives in a processed polymer by chromatography.	
	9	Calculate weight percentage of inorganic and organic ingredients in polymericcompounds.	
	10	To determination of purity of monomers by spectrophotometer	

References:

1. Willard H.H., Merritt L.L., Dean J.A. Instrumental method of analysis, Wadsworth Publishing Company, 1988.
2. Skoog D.A, Principle of Instrumental Analysis, Harcourt College Pub, 1997.
3. Shah V., Handbook of Plastic Testing, Technology, Wiley-Inter science., 2007.
4. Banwell C.N., McCash E.M., Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill. , 2008.
5. Maus, A. Characterization and Analysis of Polymers, Wiley and Sons. , 2008.
6. Malik, A. Mays, J. Shah, M. R. Molecular Characterization of Polymers: A Fundamental Guide, Elsevier., 2021.
7. Tanaka T., Experimental Methods in Polymer Sciences, Academic Press., 1999.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Students will grasp the fundamental principles underlying chromatographic separation techniques as applied to polymer analysis and learn to interpret chromatograms obtained from various chromatographic techniques	**U, Ap**	**7**
CO-2	Learn about the interaction of electromagnetic radiation with polymer molecules and how it provides valuable information about their structure and properties and Able to identify characteristic peaks, analyse peak shapes, and correlate spectral features with specific polymer structures and functional groups	**U, E, Ap**	**7**
CO-3	Students will gain a comprehensive understanding of the principles underlying microscopic and X-ray techniques as applied to polymer analysis. Develop proficiency in microscopic and X-ray instrumentation commonly used in polymer characterization,	**U, R,Ap**	**7**
CO-4	Develop a comprehensive understanding of the thermal and mechanical behaviour of polymers, including concepts such as glass transition temperature, melting point, crystallinity, modulus, strength, and toughness and Learn about the relationship between polymer structure, processing, and resulting properties	**U, R, An, E**	**1**
CO-5	Understand how molecular weight determination techniques complement other analytical methods in polymer analysis and Learn to interpret molecular weight data obtained from different techniques	**U,An,E**	**7**
CO-6	Student Identification of different spectral methods for polymer characterization in laboratory.	**Ap**	**4**

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

Name of the Course: Characterization Techniques for Polymers
Credits: 3:0:1 (Lecture: Tutorial:Practical)

CO No.	Course Outcomes	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Students will grasp the fundamental principles underlying chromatographic separation techniques as applied to polymer analysis and learn to interpret chromatograms obtained from various chromatographic techniques	**7/7**	**U, Ap**	**F, C**	**L**	
CO-2	Learn about the interaction of electromagnetic radiation with polymer molecules and how it provides valuable information about their structure and properties and Able to identify characteristic peaks, analyse peak shapes, and correlate spectral features with specific polymer structures and functional groups	**4/7**	**U, E, Ap**	**C**	**L**	
CO-3	Students will gain a comprehensive understanding of the principles underlying microscopic and X-ray techniques as applied to polymer analysis. Develop proficiency in microscopic and X-ray instrumentation commonly used in polymer characterization,	**5/7**	**U, R,Ap**	**C**	**L**	
CO-4	Develop a comprehensive understanding of the thermal and mechanical behaviour of polymers, including concepts such as glass transition temperature, melting point, crystallinity, modulus, strength, and toughness and Learn about the relationship between polymer structure, processing, and resulting properties	**4/1**	**U, R, An, E**	**F,C**	**L**	
CO-5	Understand how molecular weight determination techniques complement other analytical methods in polymer analysis and Learn to interpret molecular weight data obtained from	**6/7**	**U,An, E**	**C**	**L**	

	different techniques					
CO-6	Student Identification of different spectral methods for polymer characterization in laboratory.	**3,4/4**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs:

	PSO-1	PSO4	PSO-7	PO-3	PO4	PO5	PO6	PO7
CO 1	-	-	2	-	-	-	-	3
CO 2	-	-	3	-	2	-	-	-
CO 3	-	-	2	-		2	-	-
CO 4	2	-	-	-	3		-	-
CO 5	-		3	-	-	-	3	-
CO 6	-	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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6SECPOC301**				
Course Title	Fiber Technology				
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	Knowledge in Fibre Technology and Nanofibre				
Course Summary	To study the basic concept of natural and Synthetic Fibres. Apply the knowledge of preparation of some Natural Fibres.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**NATURAL AND SYNTHETIC FIBRES**	9
	1	Introduction to Fibres. Classification of Fibres. General properties of natural and synthetic fibres.	2
	2	Natural fibres: Natural fibres of vegetable, seed and fruit origin , natural fibres of animal origin-silk, natural mineral fibre, Boron fibre, ceramic fibre and alumina fibre. Synthetic Fibres: Introduction, semi-synthetic fibres from cellulose, regenerated protein fibres, synthetic fibres-rayon, polyethylene terephthalate, Nylon6 and Nylon 66, polyolefin, polyvinyl chloride, polyvinyl alcohol. Miscellaneous fibres: Carbon fibre, glass fibre.	3
	3	Definition of man-made fibres, Brief outline of manufacture of textiles: Fibres to yarn, yarns to fabrics-weaving, knitting, braiding, compound fabric constructions, finishing processes, dyeing and printing.	2
	4	Comparative study of properties of Natural fibres and synthetic fibres. General applications of Natural and Advanced fibres.	2
II		**PREPRATION,CHARACTERISATION AND PROCESSING OF FIBRES**	9
	5	General properties of fibres such as moisture absorption, fineness (tex, denier), tensile strength (elongation at break, elastic recovery, tenacity) Textile fibres and its properties: textile fibre, properties of textile fibres-primary properties and secondary properties Primary properties- length to width ratio, tenacity, cohesiveness or spinning properties, flexibility, uniformity.	4

		Secondary properties: physical shape, lustre, specific gravity, elongation, moisture regain and moisture content, resiliency, thermal behaviour, biological properties.	
	6	Fibre identification tests: visual examination, microscopic test, burning test and chemical test. Processing fibres: Introduction to spinning, classification of spinning processes. Fibre spinning process: melt spinning process, wet spinning process, and Dry spinning process.	3
	7	Processing of cotton fiber: types of cotton fibers, properties of cotton fibers, molecular structure of cotton fibers, cultivation of cotton fibers. Uses of cotton fibers.	2
III	**METHODS OF NANO FIBRE PRODUCTION AND NANO FIBRE TECHNOLOGY**		9
	8	General introduction of nanotechnology, Polymer nanoparticles, Classification of nanoparticles. General properties of nanoparticles. Technology of nano- fibres: definition of nano-fibre, manufacturing techniques of nano-fibres: bicomponent extrusion, template synthesis, phases separation, drawing, spinning processes.	4
	9	General properties of nanofibres. Merits of nanofibres over conventional fibres. Manufacturing of simple nano -fibres [cellulose, banana fibre]	3
	10	Applications of nanofibres in drug delivery, tissue engineering, Nanofabrics, waste management treatment.	2
IV	**PRACTICAL ANALYSIS OF FIBRES**		**9**
	11	Determine the denier of the given fibre sample.	1
	12	To determine fineness (denier,tex,count) of given fibres, filaments, yarns.	2
	13	To analyse the reaction of fibres to heat and flame.	2
	14	To Investigate the diametric swelling of fibres.	1
	15	To identify the fibre through solubility test	2
	16	To determine primary properties of textile fibre	1
V	**EXPLORE REAL WORLD APPLICATION AND PROBLEM SOLVING STRATEGIES**		9
	Preparation of natural fibre : cotton Fibre, Banana Fibre.		5
	Problem solving strategies through a visit to Textile Fabric and nano fibre technology focusing on resolving industrial challenges.		4

References:

1. F. W. Billmeyer Jr., Text Book of Polymer Science, Wiley-Inter science, 1984.
2. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, New Age Int. Pvt. Ltd., 2021.
3. Kothari V. K, Textile Fibers : Developments and Innovations, IAFL Publications 2000.
4. Vaidya A. A, Production of synthetic Fibers, 1st Ed., Prentice Hall of India 1988.
5. Nakajima T. Advanced Fiber Spinning Technology, 1st Ed., Woodhead Publisher, 2000.
6. David S. R, Structure Formation in Polymeric Fibers, Hanser publications, 1st Ed., 2000.
7. NPTEL course material on manufactured fiber technology.
10. Cook J. G Hand Book of Textile Fiber, Woodhead publications 2009.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to:**	**Cognitive Level**	**PSO addressed**
CO-1	Study the importance of fibre in technology.	**U, R**	**1,2**
CO-2	Remember the knowledge about spinning techniques and apply the knowledge to prepare fibre with a particular method for production of natural fibres.	**U, Ap, An**	**2,5**
CO-3	Understand the importance of nano-fibre in everyday life.	**U,Ap**	**2,5**
CO-4	Apply the knowledge of preparation of fibres and analysis of Fibres.	**R, Ap**	**3**
CO-5	Recognize the diverse applications of Fibres in industries, appreciating their versatility and significance in various fields.	**An, Ap, C**	**6**
CO-6	Gain practical exposure to real-world industrial applications and problem-solving strategies through a	**R, Ap,An**	**7**

	visit to a textile factory, fostering collaboration and innovation in resolving industrial challenges.		

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

Name of the Course: Fiber Technology

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

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Conceptual understanding various definitions of fibres.	**1/1,2**	**U**	**C**	**L**	
CO-2	Understand reactions and production in fibres.	**2,6/2,5**	**U, R**	**P, F**	**L**	
CO-3	Understanding the various spinning techniques	**3,5/2,5**	**U, An**	**P, C**	**L**	
CO-4	Understanding nanofibres in everyday life	**1,2/3**	**U, R, Ap**	**F, P**	**L**	
CO-5	Obey lab safety rules and prepare some natural fibres	**6/6**	**An, C, R**	**C, F, P**		**P**
C0-6	Develop skill in preparing and analysis of nanofibres.	**2,5/7**		**M**		**P**

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

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 5	PSO 6	PSO7	PO1	PO2	PO3	PO4	PO 5	PO 6
CO 1	1	2		-	-	-	1	-	-	-	-	-
CO 2		2		3	-	-	-	1	-	-	-	2
CO 3	-	3		1	-	-	-	-	1	-	3	-
CO 4	3	2		-	-	-	1	2	-	-	-	-
CO 5	2	1	3	-	-	-	-	-	-	-		3
CO 6	-	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
- Project Evaluation
- 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			✓	

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6SECPOC302**				
Course Title	Rubber Technology				
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	Knowledge in extraction and Rubber processing Technology				
Course Summary	To learn about the processes of vulcanization and properties of Natural Rubber. Evaluate testing of rubber materials using different testing instruments.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		Introduction to Rubber Technology	**9**
	1	Introduction to polymers, Classification of polymers. Thermoplastics, Thermosets, Elastomers and Fibres. Elastomers -Natural rubber, semi-synthetic, synthetic rubber.	2
	2	Natural rubber latex and its cultivation, Collection, Preservation and concentration of latex, Properties and applications of natural and synthetic rubber.	3
	3	Synthetic Rubbers: brief introduction to rubber technology, rubbers from stereo- regular polymerization of isoprene and butadiene, SBR, CR, NBR, IIR, EPDM. Thermoplastic Elastomers.	2
	4	General properties and applications of synthetic rubbers.	2
II		**RUBBER COMPOUNDING AND PROCESSING TECHNOLOGY**	**9**
	5	Introduction to rubber compounding, Rubber additives-fillers, Rubber vulcanisation agent, Sulphur donor, metal oxide, accelerators, activators, antidegrandants, special additives, colorants, extenders. Reclaimed rubber.	3
	6	Need for compounding- rubber mixing mechanisms-mixing machinery-two roll mill-internal mixers- machine design- mixing in internal mixers and two roll mill, continuous mixers- mixing cycles and procedure operating variables and mix quality.	3
	7	Vulcanization of Rubber: theory and mechanism of sulphur and non- sulphur vulcanization, rheocurve of compounded	3

		rubber, pre and post vulcanization processes, properties of vulcanization rubber. Sulphur Vulcanization: Accelerators, Retarders, Activators, theory of vulcanization and accelerators action, non-sulphur vulcanization, hard rubber and ebonite.	
III	**PRODUCT DESIGN MANUFACTURING**		**9**
	8	Quality test for compounding ingredients: Solubility, specific gravity, melting point, compound design and preparation. Preparation of compounding: two roll mixing mill, principles of latex compounding, Basics of latex compounding.	3
	9	Physical testing- stress-strain measurements, tensile strength, hardness, tear resistance, resilience, abrasion resistance, impact resistance. Electrical properties-resistivity, dielectric constant, electrical breakdown, power factor.	3
	10	Mastication, master batching, final mixing. Compounding stages; master batch mixing, re pass stage mixing, final compound mixing. Moulding techniques – compression moulding, transfer moulding, extrusion moulding, calendaring. Some major rubber products- tyres, belting and hoses, cellular products, miscellaneous applications of rubbers.	3
IV	**PRACTICAL ANALYSIS OF POLYMERS**		**9**
	11	Chemical analysis of raw rubber and products: i) specific gravity, moisture content, viscosity.	2
	12	Important tests for characterising rubbers by chemical methods: visual examinations, ignition tests, boiling point and elemental analysis.	2
	13	Estimation of latex: Dry Rubber Content, Total Solid Content, Total alkalinity, magnesium content.	3
	14	Determination of tensile strength, modulus, elongation at break, tear strength, abrasion resistance, heat build – up resilience, hardness for rubber compounds.	2
V	15	**PHYSICAL PROPERIES AND INDUSTRIAL VISIT**	**9**
	16	Determination of curing time on physical properties of NR Compounds.	2
	17	To determine viscosity using Mooney viscometer	2
	18	Explore the real world applications and problems solving strategies through a visit to Rubber Industry and Rubber Board focusing on resolving industrial challenges.	5

References:

1. F. W. Billmeyer Jr., Text Book of Polymer Science, Wiley-Interscience, 1984.

2. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, New Age Int. Pvt. Ltd., 2021.
3. M. Morton, Rubber Technology, Chapman Hall, 1995.
4. J. Brydson, Rubber Chemistry, Butterworths, 1978
5. B. Kothandaraman, Rubber Materials, Ane Books, 2008.
6. I. Franta, Elastomers and Rubber Compounding materials, Elsevier, 1989.
7. J. Urbanski, W. Czerwinski, K. Janicka et al., Handbook for analysis of synthetic polymer and plastics, Ellis Harwood Ltd., 1978.
8. Martin J.E, Smith W.K, Handbook of Rubber Technology, CBS Publisher, 2007.
9. Blow S, Handbook of Rubber Technology, Hanser Gardner, 2000.

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**	**1,2**
CO-2	Understand the rubber vulcanisation and compounding	**U,Ap,An**	**1,2**
CO-3	To identify the key tools used in industry of processing of rubber. Familiarity with the various additives used in rubber industry	**Ap**	**1,2**
CO-4	Understand the importance of product design manufacturing	**R, Ap**	**5**
CO-5	Application of technology in polymer processing	**U, Ap, C**	**6**
CO-6	Gain practical exposure to real-world industrial applications and problem-solving strategies through a visit to a rubber factory, fostering collaboration and innovation in resolving industrial challenges.	**An, Ap**	**4**

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

Name of the Course: Rubber Technology

Credits: 3:0:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Conceptual understanding various definitions of Elastomers, fibres, thermosets.	**1,3/1,2**	**U**	**C**	**L**	
CO-2	Understand the importance of natural and synthetic elastomers	**2,6/1,2**	**U, R**	**P, F**	**L**	
CO-3	Understanding the various vulcanizing techniques.	**1,5/1,2**	**U, An**	**P, C**	**L**	
CO-4	Properties and the applications of natural and synthetic elastomers.	**2/5**	**U, R, Ap**	**F, P**	**L**	
CO-5	Understand the product design manufacturing.	**5/6**	**An, C, R**	**C, F, P**		**P**
C0-6	Develop skill in preparing and analysis of rubber products	**1/4**		**M**		**P**

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

Mapping of COs with PSOs and POs:

	PSO	PSO	PSO	PSO	PSO	PO1	PO2	PO3	PO4	PO5	PO6

	1	**2**	**4**	**5**	**6**						
CO 1	1	2	-	-	-	1	-	1	-	-	-
CO 2	2	2	-	-	-	-	2	-	-	-	3
CO 3	2	3	-	-	-	1	-	-	-	3	-
CO 4	-	-	-	3	-	-	1	-	-	-	-
CO 5	-	-	-	-	3	-	-	-	-	3	-
CO 6	-	-	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
- Project Evaluation
- 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			✓	

Discipline	POLYMER CHEMISTRY				
Course Code	**UK6SECPOC303**				
Course Title	Plastic Technology				
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	Basic knowledge of chemistry at Higher Secondary level General awareness about the polymers				
Course Summary	Natural Synthetic Plastic, Compounding for Specific Properties, Techniques for Characterization				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Natural & Synthetic Plastic**	**9**
	1	Basic chemistry of polymers-nomenclature of polymers sources for raw materials. Methods of manufacturing – properties and applications of Natural Polymers - Shellac resin, natural rubber, Cellulosics.	4
	2	Preparation- properties - and applications of Polyolefine- Polyethylene- LDPE -LLDPE- HDPE,HMWHDPE- UHMWHDPE -	2
	3	Crosslinked polyethylene- Chlorinated polyethylene – Polypropylene –Homo & Co polymer. Preparation - properties - and applications of Vinyl plastics.	3
II		**Compounding for Specific Properties**	**9**
	4	Compounding - Selection of polymers and compounding-ingredients-general objectives- Merits and demerits of additives in polymer matrices.	3
	5	Mixing and mixing equipments. Compounding by batch mixer-High speed mixer - Two roll mill - Banbury Mixer - Ribbon blender - Planetary mixers.	3
	6	Fillers and Reinforcement– Antioxidants-Thermal Stabilisers, Ultraviolet stabilizer– Impact Modifiers/ Toughening agents. Colourants-Fire retardants-Coupling agents-blowing-agents Plasticizers- Antistatic agents-Anti blocking agents-Slip and anti slip agents-processing aids - Lubricants- mould releasing agents, Additives for recycling.	2
III		**Techniques for Characterization**	**9**

	7	Characterization Principles and analysis of polymer samples- FTIR, DSC, TGA	**2**
	8	Characterization Principles and analysis of polymer samples- DMA, XRD, SEM,TEM	**2**
	9	Characterization Principles and analysis of polymer samples- GPC, TMA, GC,	**3**
	10	Characterization Principles and analysis of polymer samples- AAS, TEM, XRF.	**2**
IV	**Product Design and Manufacturing**		**9**
	11	Introduction to Molding process and Moulds – Classification of moulds	**2**
	12	Factors considered for Mould Design-Shot Capacity-Plasticizing Rate-Clamping Force- Injection Time – Cooling Time - Number of Cavities –Layout of Cavities.	**2**
	13	Injection moulds: Classification. Feed System, Ejection System, design of mould temperature control system Compression Mould Design, Transfer Mould Design	**2**
	14	Blow Mould Design, Rotational Mould Design, Extrusion Die Design.	**3**
V	**Case Study and Product Modification**		**9**
	15	Case studies on preference of one plastics to other and co-relation of properties of conventional materials and blends - case studies on application of blends.	1
	16	Identifying problem and reviewing literature in regard with the study	4
	17	Discussion and Inference	2
	18	Result and conclusion	1
	19	Presentation of report	1

References:

1. Peter Jones, The Mould Design Guide, Rapra Technology Limited, 2008,
2. Sanjay K Nayak, Pratap Chandra Padhi and Y. Hidayathullah, Fundamentals of plastics mould design, McGraw Hill Education, 2012
3. Allen; W.S and Baker; P.N, Hand Book of Plastics Technology, CBS Publishers, 2020
4. Al Malaika; S. Golovoy; A and Wilkie (Eds), Chemistry and Technology of Polymer Additives, Black well Science Ltd, Oxford, 1999

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Will develop understanding on Natural Synthetic Plastic	**U**	**5**
CO 2	Will understand mechanism of Compounding for Specific Properties	**U**	**1**
CO-3	Will develop innovative ideas to Product Design and Manufacturing	**C**	**5**
CO-4	Will characterize Polymers by modern Techniques	**E**	**6**

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

Name of the Course: Plastic Technology

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

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Will develop understanding on biodegradable polymers	**1/5**	**U**	**F, C**	**L**	
CO 2	Will understand mechanism of degradation of polymers	**1/1**	**U**	**P**	**L**	
CO-3	Will develop innovative ideas to create biofriendly polymers	**3/5**	**C**	**M**	**L**	
CO-4	Will assess bio-degradability of polymers	**1/6**	**E**	**P**	**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	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	-	2	-	3					
CO 2	3	-	-	-	-	-	2					
CO 3	-	-	-	-	3	-			3			
CO 4	-	-	-	-	-	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
- Project Evaluation
- Final Exam

Mapping of COs to Assessment Rubrics :

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

Discipline	POLYMER CHEMISTRY				
Course Code	**UK7DSCPOC401**				
Course Title	Advanced Polymer Chemistry 1				
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.Studying specialty polymers requires a solid understanding of polymer chemistry, including polymerization techniques and molecular structure analysis. 2. Knowledge of materials science principles is essential to comprehend the mechanical, thermal, and electrical properties of these polymers. 3. Familiarity with polymer processing methods, such as extrusion and injection moulding, aids in developing specialized polymer products 4. An understanding of application-specific requirements, such as biomedical compatibility or chemical resistance, is crucial for designing and formulating effective specialty polymer solutions.				
Course Summary	The course on specialty polymers covers polymer chemistry, materials science principles, and processing techniques like extrusion and moulding. Students learn to analyse molecular structures, study mechanical and thermal properties, and design polymers for specific applications. Emphasis is placed on understanding industry requirements, such as biomedical compatibility or chemical resistance, to formulate effective specialty polymer solutions. The course integrates theory with practical applications to prepare students for careers in polymer engineering and related fields.				

Detailed Syllabus:

Module	Unit	Contents	Hrs
I	**Qualitative identification of polymers and their Intermediates**		9
	1	Identification of polymers by heating and burning tests, identification of elements	3
	2	Functional groups, Acid value, Softening point, HDT	2
	3	Melting point, melt-flow index, bulk-density.	2
	4	Hardness, water absorption, moisture content, ash content.	2
II	**Viscoelastic properties**		9
	5	Introduction, rheological equation for state, fluids-ideal and Non-Newtonian flow.	2
	6	viscous flow, viscoelastic behaviour, stress-relaxation, dynamic mechanical behaviour,	3
	7	Generalized Maxwell model, Mechanical spectra, effect of different factors on mechanical spectra.	3
	8	General behaviours of polymer melts, measurement of flow properties.	1
III	**Polymer processing technology**		9

	9	Processing thermoplastics material, polyolefins, injection moulding, thermo forming, extrusion, General Features of single screw extrusion, mechanism of flow, Analysis of flow in Extruder, general features of twin-screw extruder, pultrusion, blow moulding and casting: introduction, details of process.	3
	10	Rotational moulding, calendaring and it's analysis, structural foaming. Moulding: sandwich moulding, RIM.	2
	11	Moulding of thermoset: preparation of material for moulding, compression moulding, transfer moulding. Effect of processing, microstructural changes, Shrinkage and distortion, residual Stress.	2
	12	Processing of fibres and fabrics, spinning and post-spinning Processes. Gel Spinning, Phase Separation Spinning, Reaction Spinning. Application of rheological aspects in polymer Processing.	2
IV	**Polymer coatings**		9
	13	Introduction to paints and enamels. Constituents of paints. Principles of paint formulation, examples of flat, semi gloss and gloss paints, flow diagram of paint manufacture.	2
	14	Ball mill, triple roll mill, bead mill, titrator, high speed and heavy-duty disperser. Chemistry of drying, semidrying and non-drying oils. Classification of varnishes and coatings, Lacquer formulation, thinners, extenders/fillers.	3
	15	Colorant and pigments: Classification of pigments, chemistry, properties and application of white pigments, examples yellow, red, metallic, black, blue, green, fluorescent, pearl pigments.	2
	16	Brief exposure to methods of analysis and testing of paints, methods of application of paints, failure of paint film – Mar Test, Anti-condensation test, Fire Resistance test disperser.	2
V	**Speciality polymers**		9
	17	I. Conducting polymers. II. Polymer liquid crystals. III. Polymers in lithography. IV. Composites and nanocomposites.	2
	18	V. Hydrogels and stimulli sensitive hydrogels, controlled release drug delivery polymer systems. VI. Polymer in optoelectronics. VII. Polymers in medicine – biomedical applications (UHMWPE, PU, Polysiloxanes).	3
	19	VIII. Polymer membranes for gas separation, per evaporation and fuel cell. IX. Silicone resins. X. Polymer blends and alloys.	2
	20	XI. Ionic polymers. XII. Polymers in tissue engineering. XIII. Self–assembling Polymers. XIV. Polymer adhesives. XV. Polymers based on Boron / Nitrogen.	2

Advanced Polymer Chemistry I Practical – 30 Hours

Detailed Syllabus:

Module	Contents	Hrs
1	Determination of hydroxyl value of a polymer/resin (2 Samples).	5
2	Determination of iodine value of a polymer/resin (2 Samples).	5
3	Determination of Saponification value of a polyesters (2 Samples).	5

4	Determination of molecular weight by Viscometry Analysis (i) PS-toluene / Benzene (ii) polyacrylamide- aqueous NaNO3 solution.	5
5	Polymer-Based paint formulation	5
6	Synthesis of Polyvinyl hydrogels	5

References

1. Joel R Fried, Polymer Science and Technology ,3Rd Edition, John Wiley and Sons, 2014,
2. Murayama, T., Dynamic Mechanical Analysis of Polymeric Material.,Amsterdam: Elsevier,1978.
3. J.D Ferry,Viscoelastic Properties of Polymers, 3rd Ed.- Wiley, New York, 1980.
4. Middleman, S., Fundamentals of Polymer Processing, New York: McGraw-Hill Book Company, 1977.
5. Nielsen, L. E., Polymer Rheology, New York: Marcel Dekker, Inc. 1977.
6. Morgan & Martens, Reinhold,The technology of paints- Varnishes and lacquers-Ed., 1968.
7. Norman I. Geynes, Glenn N. Danziger, Frederick C. Kinsler-Van Nonstrand, Formulation of organic coatings,1967.
8. Robert William Dyson, Speciality Polymers, 2nd ed., Springer verlag, 2011.
9. Dyson, R. W., ed., Specialty Polymers. New York: Chapman and Hall,1987.
10. Donald G. Frischknecht, Analysis and Performance of Engineering Polymers, Hanser Publications, 2014.
11. Fred J Davis, Polymer Chemistry-a Practical Approach,Oxford university press,2004

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Proficiency in qualitative polymer identification and functional group identification.	**An**	**3**
CO-2	Understanding the rheological equation of state, fluid behaviour and students will gain knowledge of the general behaviours of polymer melts and techniques.	**U**	**1**
CO-3	The course outcome encompasses mastery of thermoplastic and thermoset processing techniques, with an application of rheological principles in polymer processing.	**R, Ap**	**5**
CO-4	Proficiency in understanding the principles of	**U, Ap**	**1,5**

	paint formulation, constituents, manufacturing processes, colorants, pigments, coatings, varnishes, and methods of analysis, testing, and application, including knowledge of paint film failure tests.		
CO-5	Students will gain comprehensive knowledge and practical skills in various advanced applications of polymers, ranging from conductive polymers and liquid crystals to biomedical applications, optoelectronics, gas separation membranes, and self-assembling polymers.	**An,C**	**1,4**
CO-6	Students will master key analytical techniques such as hydroxyl, iodine, and saponification value determination, along with molecular weight analysis via viscometry, culminating in hands-on experience with polymer-based paint formulation and polyvinyl hydrogel synthesis.	**Ap**	**3**

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

Name of the Course: Adavanced polymer chemistry I Credits: 3:0:1(Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Proficiency in qualitative polymer identification and functional group identification.	**6/3**	**An**	**F**	**L**	
CO-2	Understanding the rheological equation of state, fluid behaviour and students will gain knowledge of the general behaviours of polymer melts and techniques.	**1/1**	**U**	**C**	**L**	
CO-3	The course outcome encompasses mastery of thermoplastic and thermoset processing techniques, with an application of rheological principles in polymer processing.	**3/5**	**R, Ap**	**F**	**L**	
CO-4	Proficiency in understanding the principles of paint formulation, constituents, manufacturing processes,	**6/1,5**	**U, Ap**	**F**	**L**	

	colorants, pigments, coatings, varnishes, and methods of analysis, testing, and application, including knowledge of paint film failure tests.					
CO-5	Students will gain comprehensive knowledge and practical skills in various advanced applications of polymers, ranging from conductive polymers and liquid crystals to biomedical applications, optoelectronics, gas separation membranes, and self-assembling polymers.	**5/1,4**	**An**	**F**	**L**	
CO-6	Students will master key analytical techniques such as hydroxyl, iodine, and saponification value determination, along with molecular weight analysis via viscometry, culminating in hands-on experience with polymer-based paint formulation and polyvinyl hydrogel synthesis.	**5/3**	**Ap**	**P**		**P**

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

Mapping of COs with PSOs and POs :

	PSO1	**PSO3**	**PSO4**	**PSO5**	**PO1**	**PO3**	**PO5**	**PO6**
CO 1	-	3	-	-	-	-	-	2
CO 2	2	-	-	-	3	-	-	-
CO 3	-	-	-	3	-	2	-	-
CO 4	3	-	-	2	-	-	-	3
CO 5	2	-	3	-	-	-	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	✓			✓

Discipline	POLYMER CHEMISTRY
Course Code	**UK7DSCPOC402**
Course Title	Advanced Polymer 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	Basic concepts in Chemistry of plastic materials
Course Summary	1. Understand and apply the knowledge of adhesives and Tyre technology in practical life. 2. Know how to effectively use this knowledge to design new polymer systems.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Latex Science**	9
	1	Definition of Latex, classification, Latex particle size and distribution, stability and destabilization of latices.	2
	2	Comparison between latices and polymer solution. Characteristic and processing of natural rubber latex. Latex Film Formation: Exploring the mechanisms and factors influencing the formation of latex films, including drying kinetics, coalescence, and film morphology.	2
	3	Rheology of Latex: Understanding the rheological properties of latex dispersions, including viscosity, shear thinning behaviour, and viscoelasticity, and how to model and analyse these properties using LaTeX. Latex Nanocomposites: Typesetting information on the preparation, characterization, and properties of latex nanocomposites incorporating nanoparticles such as clays, carbon nanotubes, or graphene.	2
	4	Latex Blending and Copolymerization: Describing the blending of different latex formulations or the copolymerization of monomers in latex systems, including methods, characterization, and applications. Latex Modification and Functionalization: Detailing techniques for modifying latex particles, such as surface functionalization, grafting, crosslinking, and encapsulation, and their impact on properties.	3
II		**Latex application**	9
	5	Industrial Application of Latex products – Dipped, Foamed, Cast and Spread.	3
	6	Latex Rubber Products in Daily Life: Gloves, Balloons, Condoms, and Elastic Bands. Latex Rubber in Textiles: Clothing, Swimwear, Lingerie, and Accessories. Household and Industrial Applications of Latex Rubber: Adhesives, Sealants, and Foams	3
	7	Latex Rubber in Automotive Industry: Tires, Seals, and Gaskets.	2

		Construction and Building Materials Containing Latex Rubber: Adhesives, Coatings, and Sealants	
	8	Latex Rubber in Medical Devices and Healthcare Products: Gloves, Catheters, and Surgical Instruments	1
III		**Rubber based adhesives**	9
	9	Introduction to Adhesives, the role of Adhesives in the economy, fundamentals of adhesion, surface preparation for adhesion bonding, adhesive selection and screening.	3
	10	Natural Adhesive Materials-Animal glue, casein and mix protein adhesives, starch base adhesives	2
	11	Natural rubber adhesive, butyl rubber and polyisobutylene, nitrile rubber adhesive, styrene butadiene rubber adhesive	2
	12	Thermoplastic rubber in adhesive, carboxylic polymers in adhesive, neoprene based solvent and latex adhesive, polysulfide sealant and adhesives.	2
IV		**Resin based reactive adhesives**	9
	13	Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – Uses of adhesives in civil engineering, automobile, aerospace, electrical & electronic industries.	2
	14	Application of Phenolics Adhesives in Railway Infrastructure Maintenance, Epoxy Adhesives for Composite Material Bonding in Marine Engineering, Acrylics Adhesives in Signage and Display Manufacturing, Anaerobics Adhesives for Industrial Pump Sealing Applications.	3
	15	Cyanoacrylates Adhesives for Rapid Prototyping in 3D Printing, Adhesive Bonding Techniques in Offshore Oil and Gas Structures, Automotive Adhesives for Lightweighting Electric Vehicles, Aerospace Structural Adhesives for Spacecraft Assembly	2
	16	Electrical Insulation Adhesives for High Voltage Equipment, Adhesive Technologies in Renewable Energy Systems, Advanced Adhesive Applications in Medical Device Manufacturing.	2
V		**Tyre science and Technology**	9
	17	A historical introduction on the design and development of tyres of various kinds and type the current status of tyre industry in India and its future prospects, tyre sizing and marking on the tyres, different types of tyres bias-belted tyre, tube and tubeless tyre, their basic functions and performance comparisons.	2
	18	Different components of a tyre, its geometry, basic functions. Functions of a pneumatic tyre-load carrying, vibration and noise reduction, tyre function as a spring, contribution to driving control and road adhesion, the tyre friction contribution to driving control, steering control and self aligning torque.	3
	19	Manufacturing techniques of various tyres like two wheeler and car tyres, truck tyres, OTR, farm tyres, aircraft tyres. Principles of designing formulations for various rubber components. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection, different styles and construction, textile treatment.	2
	20	Tyremould design, green tyre design principles, methods of building green tyres for bias, bias belted, radial and tubeless tyres, green tyre	2

		treatments. Tyre curing methods, post cure inflation, quality control tests. Tyre related products, their design and manufacturing techniques, tubes, valvesflaps, bladders.	

Advanced polymer chemistry II Practical – 30 Hrs
Detailed Syllabus:

Module	Unit	Contents	Hrs
I		Design & development of	10
	1	Tyre tread material	
	2	Hose cover	
	3	Conveyor belt cover	
	4	Gasket compound	
	5	footwear compound	
	6	latex dipped products	
	7	rubber mats	
	8	door profiles	
II	9	Develop Epoxy based adhesive in lab	10
	10	Develop PU based adhesive in lab	
	11	Develop TPE based adhesive in lab	
	12	Develop adhesive for roofing applications	
	13	Develop sealants based on thermoplastics	
	14	Develop sealants based on thermoset materials	
	15	Develop Adhesives for furniture industry	
	16	Develop adhesives for piping systems	
	17	Study adhesives used by electronic industry	
	18	Study sealants used by pharmaceutical industries.	
III		Describe the procedure to carry out tests for latex, such as:	10
	19	- Specific Gravity,	
	20	- Volatile loss,	
	21	- Moisture,	
	22	- Particle size,	
	23	- Ash Content,	
	24	- Melting Point, Boiling Point, Softening Point,	
	25	- pH, etc.	

References

1. E. Desmond Goddard and James V. Gruber. Principles of Polymer Science and Technology in Cosmetics and Personal Care, 1st Edition, 1999, CRC Press.
2. E. S. Daniels, E. D. Sudol and M. S. El-Aasser. Polymer latexes: Preparation, Characterization and Applications, 1992, American Chemical Society.
3. D. C. Blackley. Polymer Latices- Science and Technology, 3rd Edition, 2012, Springer Netherlands.
4. C. M. Blow. Rubber Technology and Manufacture, 1971, Newnes-Butterworth.
5. David M. Hill. Latex Dipping- Science and Technology, De Gruyter.
6. Rani Joseph. Practical Guide to Latex Technology, 2013, Smithers Rapra.
7. Frederick Marchionna. Latex and Its Industrial Applications, 1937, Rubber Age Publishing Company.

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11. Shinzo Kohjiya and Yuko Ikeda. Chemistry, Manufacture and Applications of Natural Rubber, 2nd Edition, 2021, Elsevier.
12. W. Hoffmann. Rubber Technology Handbook, 1989, John Wiley & Sons.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Able to understand the basics of latex science and also different types of modification techniques.	**U, R**	**1,3,5**
CO-2	Understanding of the application of various industries.	**U, R**	**1,3,5**
CO-3	Able to understand the different types of rubber based adhesives and role in the economy	**U, R**	**1,3,5**
CO-4	Understand the different types of resin based reactive adhesives and their applications	**U, R**	**1,3,5**
CO-5	Understand the tyre science and technology	**U, R**	**1,3,5**
CO-6	Analyse the quality of latex. Develop the ability to make different types of latex based products and adhesives.	**U, Ap, An**	**6,7,8**

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

Name of the Course: Advanced Polymer Chemistry II
Credits: 3:0:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Able to understand the basics of latex science and also different types of modification techniques.	**1/1,3,5**	**U, R**	**C**	**L**	
CO-2	Understanding of the application of various industries.	**1/1,3,5**	**U, R**	**C**	**L**	
CO-3	Able to understand the	**3/1,3,**	**U, R**	**C**	**L**	

	different types of rubber based adhesives and role in the economy	**5**				
CO-4	Understand the different types of resin based reactive adhesives and their applications	**1/1,3, 5**	**U, R**	**C**	**L**	
CO-5	Understand the tyre science and technology	**1/1,3, 5**	**U, R**	**C**	**L**	
CO-6	Analyse the quality of latex. Develop the ability to make different types of latex based products and adhesives.	**3,6,7, 8/6,7, 8**	**U, Ap, An**	**P**		**P**

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

Mapping of COs with PSOs and POs

	PSO1	**PSO2**	**PSO3**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PO 1**	**PO 2**	**PO 3**	**PO6**	**PO7**	**PO8**
CO 1	2	-	2	2	-	-	-	2	-	-	-	-	-
CO 2	2	-	2	2	-	-	-	2	-	-	-	-	-
CO 3	2	-	2	2	-	-	-	-	-	2	-	-	-
CO 4	2	-	2	2	-	-	-	2	-	-	-	-	-
CO 5	2	-	2	2	-	-	-	2	-	-	-	-	-
CO 6	-	-	-	-	2	2	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	✓		✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK7DSCPOC403**				
Course Title	Advanced Inorganic and 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
	3	3hours	-	2	5
Pre-requisites	Basic knowledge on quantum mechanics, group theory, electrochemistry, thermodynamics and properties of transition metal complexes.				
Course Summary	Advanced Inorganic and Physical Chemistry gives a opportunity to learn about basics of quantum mechanics, group theory, electrochemistry and advanced thermodynamics and Spectral and magnetic properties of transition metal complexes. It also includes practical experiments physical chemistry analysis and providing students with hands-on experience in the laboratory.				

Detailed syllabus

Module	Unit	Course Description	Hrs
I		**Quantum Mechanics II**	9
	1	Postulates of quantum mechanics: State function postulate: Born interpretation of the wave function, well behaved functions, orthonormality of wave functions.	1
	2	Operator postulate: Operator algebra, linear and nonlinear operators, Laplacian operator, commuting and non-commuting operators, Hermitian operators and their properties.	1
	3	Eigen value postulate: eigen value equation, eigen functions of commuting operators.	1
	4	Expectation value postulate. Postulate of time Dependent Schrödinger equation, Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta (Lx, Ly, Lz and L^2) - expression for (L_x, L_y, L_z and L^2) in polar coordinates.	2
	5	Application of Quantum mechanics to Exactly Solvable Model Problems Translational motion: free particle in one dimension, particle in a box with infinite potential barrier one dimensional box three-dimensional box and cubical box-degeneracy.	2
	6	Particle with finite potential barriers, one potential barrier, two finite barriers. Quantum mechanical tunnelling (Qualitative concept only).	2
II		**Group Theory - II**	9
	7	Symmetry elements and symmetry operation. Matrix representation of symmetry operations. Block factored matrices, Character of a matrix. Conditions for a set of elements to form a group. Point groups and their systematic identification.	1

	8	Multiplication of operations. Group multiplication table. Similarity transformation and classification of symmetry operation, Matrix representation of point group. Reducible and Irreducible representations.	2
	9	The Great Orthogonality Theorem. Rules derived from GOT (proof not required).	1
	10	Setting up of character table of C_{2v}, C_{3v} and C_{2h} groups. Direct product representations. Reduction formula, reduction of reducible representation to IRs. Transformation properties of atomic orbitals. Molecular symmetry and optical activity. Determination of number of active IR and Raman lines taking simple molecules	3
	11	Applications of character tables: Hybridisation- identification of atomic orbitals taking part in hybridisation of triangular planar, square planar, trigonal bipyramidal, square pyramidal and tetrahedral molecules.	2
III		**Applications of Thermodynamics**	9
	12	General theory of non-equilibrium processes. The phenomenological relations. Onsager reciprocal relation. Principle of minimum entropy production.	1
	13	Generalized equation for entropy production, Entropy production from heat flow, matter flow and current flow.	2
	14	Application of irreversible thermodynamics to diffusion. Thermal diffusion, thermo osmosis and thermo-molecular pressure difference.	2
	15	Electro-kinetic effects, the Glansdorf-Pregogine equation. Far from equilibrium region.	2
	16	Three component systems: Graphical representation. Three component liquid systems with one pair of partially miscible liquids. Influence of temperature. Systems with two pairs and three pairs of partially miscible liquids.	2
IV		**Coordination chemistry-: Spectral and magnetic properties of transition metal complexes**	9
	17	Electronic spectra of metal complexes-Term symbols of d^n system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields.	2
	18	Correlation diagrams for d^n and d^{10-n} ions in octahedral and tetrahedral fields (qualitative approach), d-d transition, selection rules for electronic transition, effect of spin orbit coupling and vibronic coupling.	2
	19	Interpretation of electronic spectra of complexes- Orgel diagrams, Tanabe-Sugano diagrams, calculation of Dq , B and β (Nephelauxetic ratio) values, charge transfer spectra.	2
	20	Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility, Gouy's method for the determination of magnetic moment of complexes, spin only magnetic moment. Temperature dependence of magnetism. Temperature Independent Paramagnetism (TIP). Spin state crossover, Antiferromagnetism - inter and intra molecular interaction.	2

	21	Application of magnetic measurements in the determination of structure of transition metal complexes.	1
V		**Electrochemistry**	9
	22	Ionics: Activity and activity coefficient of electrolytes, determination of activity coefficient.	1
	23	Debye-Huckel theory of strong electrolytes, Debye-Huckel-Onsager equation and its derivation, limitation of the model, conductance at high frequencies and high potentials –Wein effect and Debye - Falkenhagen effect.	2
	24	Ionic strength, Debye - Huckel limiting law, mean ionic activity coefficient.	1
	25	Electrodics: Different type of electrodes. Electrochemical cells, EMF of concentration cells, liquid junction potential and its determination, cells without liquid junction potential.	2
	26	Electrical double layer and electro capillarity. Electrokinetic phenomena.	1
	27	Over potentials: Butler-Volmer equation. Tafel and Nernst equation, Tafel plot and its significance.	1
	28	Fuel cells: H_2-O_2, zinc-air and solid oxide fuel cells.	1

Advanced Inorganic and physical chemistry Practicals: 30 Hrs

Module	Unit	Contents	Hrs
I		**Potentiometry**	20
	1	Determination of emf of Daniel cell and temperature dependence of emf of a cell.	
	2.	Titrations involving redox reactions – Fe^{2+} vs $KMnO_4$, $K_2Cr_2O_7$, $(NH_4)_2Ce(SO_4)_2$ and KI vs $KMnO_4$	
	3.	Determination of the emf of various $ZnSO_4$ solutions and hence the concentration of unknown $ZnSO_4$ solution.	
	4.	Determination of activity and activity constant of electrolytes.	
	5	Determination of thermodynamic constants of reactions.	
II	6.	**Phase rule** **Solid-liquid equilibria** A.Construction of phase diagram and determination of the composition of unknown mixture (naphthalene/ biphenyl, naphthalene/ benzophenone, naphthalene/ diphenyl amine). B.Construction of phase diagram with simple eutectic - naphthalene/ meta dinitrobenzene.	10

Reference

1. D. A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
2. R. K. Prasad, Quantum Chemistry, 3rd Edn., New Age International, 2006.
3. M. W. Hanna, Quantum Mechanics in Chemistry, Benjamin, 3rd Edn., Benjamin 1981.
4. IT. Engel, Quantum Chemistry and Spectroscopy, Pearson Education, 2006.
5. Robert L. Carter, Molecular Symmetry and Group Theory, Wiley, 1997.
6. F. A. Cotton, Chemical applications of Group theory, Wiley, 2003.

7. A Salahuddin Kunju, G Krishnan, Group Theory and Its Applications In Chemistry, Second 8.Edition, PHI Learning Pvt. Ltd, Delhi 2015.
8. A. Vincent, Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications, 2nd Edn., Wiley, 2000.
9. R. P. Rastogi, R.R.Misra, An Introduction to Chemical Thermodynamics, Vikas Publishing House, 6th edn.,1995.
10. J. Rajaram, J. C. Kuriakose, Thermodynamics, S. Chandand Co, 4th Edn., 1999.
11. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, John Wiley and Sons, 6th edition, 1999.
12. S. Glasstone, Introduction to Electrochemistry, Biblio Bazar, 2011.
13. B. K. Sharma, Electrochemistry, Krishna Prakashan, 1985.
14. V. D. Athawal, Experimental Physical Chemistry, New Age International

Course Outcomes

CO No.	*Upon completion of this course, the students will be able to*	Cognitive Level	PSO No.
CO-1.	outline the development of quantum mechanics and its tools and apply the development of quantum mechanics in determining the wave functions and energies of moving particles	**U, Ap,**	**7**
CO-2	identify point groups and construct character table and predict hybridisation and spectral properties of molecules.	**U, C**	**2**
CO-3	judge the degrees of freedom of systems and understand theories of irreversible thermodynamic systems with its applications.	**U, An, E, Ap**	**1**
CO-4	Obtain the term symbols of d^n and system determine the splitting of terms in weak and strong octahedral and tetrahedral fields and correlation diagrams for d^n and d^{10-n} ions in octahedral and tetrahedral fields and interprets electronic spectra of complexes.	**U, E**	**1**
CO-5	Applies magnetic measurements in the determination of structure of transition metal complexes.	**Ap**	**2**
CO-6	Understand theories and applications behind various types of analytical techniques in electrochemistry and Ascertain the application of electrochemistry in industrial fields.	**R, U, Ap, An**	**1**
CO-7	Develop skill in Potentiometric experiments and in constructing phase diagroms of two component and three component systems.	**Ap**	**4**

Name of the Course:Adavanced inorganic and physical chemistry
Credits: 3:0:1(Lecture:Tutorial:Practical)

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

CO-1	outline the development of quantum mechanics and its tools and apply the development of quantum mechanics in determining the wave functions and energies of moving particles	**1/7**	**U, Ap, An**	**P**	**L**	
CO-2	identify point groups and construct character table and predict hybridisation and spectral properties of molecules.	**1/2**	**U, C**	**F, C**	**L**	
CO-3	judge the degrees of freedom of systems and understand theories of irreversible thermodynamic systems with its applications.	**2/1**	**U, An, E, Ap**	**P**	**L**	
CO-4	Obtain the term symbols of d^n and system determine the splitting of terms in weak and strong octahedral and tetrahedral fields and correlation diagrams for d^n and d^{10-n} ions in octahedral and tetrahedral fields and interprets electronic spectra of complexes.	**1/1**	**U, E**	**P, C**	**L**	
CO-5	Applies magnetic measurements in the determination of structure of transition metal complexes.	**3/2**	**Ap**	**P, C**	**L**	
CO-6	Understand theories and applications behind various types of analytical techniques in electrochemistry and Ascertain the application of electrochemistry in industrial fields.	**3/1**	**R, U, Ap, An**	**C,**	**L**	
CO-7	Develop skill in Potentiometric experiments and in constructing phase diagrams of two component and three component systems	**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-4	PSO-7	PO-1	PO-2	PO-3
CO 1		-	-	3	3	-	-
CO 2	-	2	-	-	2	-	-
CO 3	3	-	3		-	3	-

CO 4	3	-	3		3	-	-
CO 5	-	3	-	-	-	-	3
CO 6	3	-		3	-	-	3
CO 7		-	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		✓		✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK7DSCPOC404**				
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	Basic stereochemistry, Organic name reactions, Principles of nmr spectroscopy, Basics of thermodynamics and kinetics.				
Course Summary	This paper aims to comprehensively explore and integrate various facets of Advanced Organic Chemistry, focusing on Stereochemistry, Physical Organic Chemistry, Photochemistry and Pericyclic Reactions, Spectroscopy, and Methods in Organic Synthesis.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Advanced Stereochemistry**	**9**
	1	Introduction to chirality and molecular symmetry, Axial stereochemistry: atropisomerism and its designation - biphenyls, allenes, spiranes. Stereoselectivity: enantioselectivity, diastereoselectivity & stereo convergence.	2
	2	Application of Cram's rule, Felkin–Ahn model. Introduction to chiral separation methods and estimation of enantiomeric excess.	2
	3	Conformational analysis of substituted cyclohexane, decalin and biased systems. Effect of conformation on reactivity of cyclohexanes.	2
	4	Introduction to ORD, CD - their application in assigning configuration.	3
II		**Physical Organic Chemistry**	**9**
	5	Kinetic and thermodynamic control of reactions with examples.	2
	6	Reaction coordinates- difference between transition state and intermediates, Energy profiles, Curtin – Hammet Principle, Hammond postulate. Principle of microscopic reversibility. Reactivity in relation to molecular structure and conformation. Steric effects, F strain. Ortho effect, Bond angle strain.	4
	7	Linear Free Energy Relations, The Hammett equation and its applications. Significance of sigma (σ) and rho (ρ) reactions with negative and positive ρ, low and high ρ, abnormal Hammet plot, Taft equation.	3
III		**Photochemistry and Pericyclic Reactions**	**9**
	8	Photoreactions of carbonyl compounds: Norrish Type I and Type II reactions of acyclic ketones.	1
	9	Patterno-Buchi and Barton reactions, Hofmann- Löffler Freytag reaction, photo-Fries and Di-π methane, oxa di π methane rearrangements	3

	10	Classification of pericyclic reactions, FMO, Correlation diagram, Mobius and Huckel theory of electrocyclic and cyclo addition reactions	2
	11	Diels–Alder, Retro–Diels Alder, Alders ene reactions, 1,3–Dipolar cycloaddition, Sigmatropic rearrangements: Cope and Claisen rearrangements.	3
IV		**Applications of NMR Spectroscopy in Organic Chemistry**	**9**
	12	Simplification methods of complex spectra by high field NMR, shift reagents, chemical exchange and double resonance.	3
	13	^{13}C NMR chemical shifts. Applications of NOE, DEPT, and 2D techniques such as COSY-HSQC, HMQC and HMBC (basic principles only).	3
	14	Spectral interpretation and structural elucidation. Solving of structural problems on the basis of numerical and spectrum-based data.	3
V		**Methods in Organic Synthesis**	**9**
	15	Retrosynthetic analysis and disconnection approach - synthons, synthetic strategy, reliable reaction, disconnect after heteroatom, chemoselectivity	2
	16	Olefin metathesis – first and second-generation Grubbs' catalysts. Umpolung concept-1,3-Dithiane	2
	17	Coupling reactions - Heck, Negishi, Sonagashira, Kumada and Suzuki coupling, Stepens-Castro coupling, Stille coupling,	3
	18	Introduction to combinatorial synthesis - split and pool method only.	2

Organic Chemistry Practical – 30 Hours

Module	Unit	Contents	Hrs
I	 1. 2. 3	Volumetric estimation of Aniline Phenol Glucose	9
II	 4. 5.	Colorimetric estimation paracetamol with potassium ferricyanide protein by biuret method	6
III	6	Spectral identification UV, IR, ^{1}H NMR, ^{13}C NMR, EI mass spectral identification of Organic compounds from a library of organic compounds (Each students have to record the spectral analysis of a minimum of 20 compounds)15	15

Reference

1. R.S. Drago, Physical Methods in Chemistry, Saunders College,1992.
2. Charles H. Depuy and Orville L. Chapman, Molecular reactions and photochemistry, 2nd edition, Prentice Hall
3. S. Sankararaman, Pericyclic reactions-A textbook: reactions, Applications and theory, Wiley-VCH, 2005.
4. D. H. Williams and I. Fleming, Spectroscopic methods in organic chemistry, 6th Edition, Tata McGraw Hill, 2011.

5. W. Kemp, Organic spectroscopy, 3rd Edition, Palgrave Macmillan, 1991.
6. F. A. Carey and R. S. Sunderg, Advanced organic chemistry, Parts A and B, 5th Edition, Springer, 2008.
7. J. Clayden, N. Greeves, S. Warren, Organic Chemistry 2nd Edn., O.U.P. India, 2023.
8. B. S. Furniss, Vogel's textbook of practical organic chemistry, 5th Edition, Longman, 1989.
9. D. L. Pavia, G. M. Lampman, G. S. Kriz and R. G. Engel, A microscale approach to organic laboratory techniques, Wadsworth Publishing, 5th Edition, 2012.
10. Niel S. Isaacs, Physical Organic Chemistry, Prentice Hall, 2nd edition, 1996.
11. Eric V. Anslyn and Dennis A. Dougherty, Modern Physical Organic Chemistry, 2006.
12. B. Smith, March's advanced organic chemistry, 7th Edition, Wiley, 2013.
13. F. G. Mann and B. C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the stability of conformations, stereoselective and stereospecific reactions.	**An, E**	**1**
CO-2	Explain the Hammet parameters of reaction and design an experiment to confirm the mechanism of a reaction.	**U, R**	**1**
CO-3	Understand that the outcomes of pericyclic reactions may be understood in terms of frontier orbital interactions, correlation diagram, Mobius and Huckel approach.	**U, R**	**1**
CO-4	State the synthetic importance of the above cycloaddition and rearrangement reactions, and give disconnections of target compounds corresponding to these reactions.	**U, Ap**	**1**
CO-5	Predict likely spectral characteristics of given molecular species; solve the structures of unknown molecules using appropriate spectroscopic techniques.	**U, Ap, An**	**6**
CO-6	Interpret data from an experiment, including the construction of appropriate graphs and the evaluation of errors.	**U, An**	**7**
CO-7	Estimate quantitatively the Aniline, Phenol, glucose, Ascorbic acid and Aspirin in a sample	**Ap**	**2,3,4**

CO-8	Estimate colorimetricaly paracetamol, protein and ascorbic acid	**Ap**	**2,3,4**

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)
CO-1	Explain the stability of conformations, stereoselective and stereospecific reactions.	**1,2,6/1**	**An, E**	**C**	**L**	
CO-2	Explain the Hammet parameters of reaction and design an experiment to confirm the mechanism of a reaction.	**1,2,3,6/1**	**U, R**	**F**	**L**	
CO-3	Understand that the outcomes of pericyclic reactions may be understood in terms of frontier orbital interactions, correlation diagram, Mobius and Huckel approach.	**1,2,3,6/1**	**U, R**	**C**	**L**	
CO-4	State the synthetic importance of the above cycloaddition and rearrangement	**1,2,3,6/1**	**U, Ap**	**C**	**L**	

	reactions, and give disconnections of target compounds corresponding to these reactions.					
CO-5	Predict likely spectral characteristics of given molecular species; solve the structures of unknown molecules using appropriate spectroscopic techniques.	**1,2,3,6/6**	**U, Ap, An**	**P**	**L, T**	
CO-6	Interpret data from an experiment, including the construction of appropriate graphs and the evaluation of errors.	**1/7**	**U, An**	**P**	**L, T**	
CO-7	Estimate quantitatively the Aniline, Phenol, glucose, Ascorbic acid and Aspirin in a sample	**1,2,3,6/2 ,3,4**	**Ap**	**M**		**P**
CO-8	Estimate colorimetricaly paracetamol, protein and ascorbic acid	**1,2,3,6/2 ,3,4**	**Ap**	**M**		**P**

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive
Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO6	PSO7	PO1	PO2	PO3	PO6
CO 1	2	1	-	-	-	-	1	1	-	1
CO 2	2	-	-	-	-	-	2	-	-	1
CO 3	2	-	-	-	-	-	1	1	1	1
CO 4	2	-	-	-	-	-	2	1	1	1
CO 5	-		-	-	2	-	1	1	1	1
CO 6	2	-	-	-	-	2	1	1	1	1
CO 7	-	1	1	2	-	-	1	1	1	1
CO 8	-	1	1	2	-	-	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	✓	✓		✓
CO 7			✓	✓
CO 8			✓	✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK7DSEPOC401**				
Course Title	Research Methodology				
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	-	-	4hours
Pre-requisites					
Course Summary					

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Research Methods**	**12**
	1	Identification and selection of the research problem, Literature survey for required information, Search engines (Scopus, Science direct, Web of science, Google scholar) for scientific information	2
	2	Encyclopaedia, Reference books, abstraction of a research paper – drawing inferences from data, - qualitative and quantitative analysis, Reference, Management Software like Zotero/Mendeley	3
	3	Software for paper writing and formatting like chem draw, origin, LaTeX and MS Office.	2
	4	Developing a research plan, Format of research proposal: individual research proposal and institutional proposal.	2
	5	Preparation of a mini review (any area) using the abovementioned software including reference	3
II		**Ethics in Research**	**12**
	6	Correct usage of technical language and scientific peer network, ethics with respect to science and research, intellectual honesty and research integrity, scientific misconduct: falsification, fabrication and plagiarism (FFP)	3
	7	Redundant publications: duplicate and overlapping publication, salami slicing, selective reporting and misrepresentation of data.	2
	8	Publication ethics: definition, introduction and importance, Best practices / standard setting initiatives and guidelines COPE (Committee on publication ethics), conflicts of interest	2
	9	Publication misconduct: definition, concept, problems that lead to unethical, behaviour and vice-versa, types, violation of publication ethics, authorship and contributor ship, identification of publication misconduct, complaints and appeals, predatory publishers and journals	3

	10	Software for detection of Plagiarism determining the mode of action, literature survey, mode of approach of actual investigation	2
III		**Research Design and Hypothesis**	**12**
	11	Research design and methods: Research design, Basic Principles- Need of research design	2
	12	Features of good design, Important concepts relating to research design, Observation and Facts, Laws and Theories, Prediction and explanation,	2
	13	Induction, Deduction, Development of Models. Developing a research plan-Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.	3
	14	Execution of the research: Observation and Collection of data, Methods of data collection, Sampling Methods	3
	15	Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.	2
IV		**Result Dissemination**	**12**
	16	Thesis and Paper writing, General format, page and chapter formation. Analysis and presentation of data, Statistical test: choosing and using suitable statistical tests. The use of quotation - footnotes - tables and figures - referencing - appendices	3
	17	Revising the paper or thesis - editing and evaluating and the final product - proof reading - the final types copy	2
	18	Presentation skill, them of conferences and workshops - Oral presentation skills – Post presentation of research outcome, Abstracts, Proceedings of technical deliberation - Publication in journals, conference proceedings and in book or as book chapters	2
	19	Components of research article - Title, abstract, key words, introduction, citations, introduction, objectives, methods, results, tables figures, graphs, discussion summary, and references. Instruction to authors by journal for writing a research paper.	3
	20	Components of proposal document- Title, aim, research background, project outline, research methodology & budgeting, time schedule, deliverables and references.	2
V		**Intellectual Property Rights**	**12**
	21	Introduction and the need for intellectual property right (IPR); Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, and Geographical Indication	2
	22	Patents - Elements of Patentability: Novelty, Non Obviousness (Inventive Steps), Industrial Application, Non - Patentable Subject Matter	3

	23	Copyrights- Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings, Registration Procedure, Term of protection, Ownership of copyright, Assignment and licence of copyright, Infringement	3
	24	Trademarks- Concept of Trademarks - Different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks) - Non Registrable Trademarks - Registration of Trademarks - Rights of holder and assignment and licensing of marks	2
	25	Geographical indication (GI): meaning, and difference between GI and trademarks - Procedure for registration, effect of registration and term of protection	2

References

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An introduction to Research Methodology, RBSA Publishers, 2002.
2. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International. 418p, 1990.
3. Sinha, S.C. and Dhiman, A.K., Research Methodology, Ess Ess Publications. 2 volumes, 2002.
4. Trochim, W.M.K., Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p, 2005.
5. Wadehra, B.L. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing, 2000.
6. Nithyananda, K V. Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited, 2019.
7. Neeraj, P., & Khusdeep, D. Intellectual Property Rights. India, IN: PHI learning Private Limited, 2014.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the importance of comprehensive literature survey and apply using appropriate methods and formats, and develop research proposals that adhere to academic standards and conventions.	**R, U, Ap**	**5**
CO-2	Understand and apply ethical principles in research practices. Analyze ethical issues that arise in	**R, U, Ap, An**	**8**

	research, and develop strategies to address them.		
CO-3	Formulate research questions, develop hypotheses, and design appropriate research methodologies.	**U, Ap**	**8**
CO-4	Analyze research results, evaluate different methods of result dissemination through research articles and proposals, and create effective strategies for communicating research findings to relevant audiences.	**An, E, C**	**4**
CO-5	Analyze the importance of intellectual property rights (IPR) in research, evaluate the implications of different IPR strategies, and create plans to protect and manage intellectual property.	**An, E, C**	**1**
CO-6	Understand various research methodologies used in polymer sciences, evaluate their appropriateness for different research questions, and create novel research methodologies to address specific challenges in the field	**U, Ap, An, E, C**	**8**

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

Name of the Course: Research Methodology Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	Course Outcome	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the importance of comprehensive literature survey and apply using appropriate methods and formats, and develop research proposals that adhere to academic standards and conventions.	**2/5**	**R, U, Ap**	**F, C**	**L**	
CO-2	Understand and apply ethical principles in research practices. Analyze ethical issues that arise in research, and develop strategies to address them.	**1/8**	**R, U, Ap, An**	**F, C**	**L**	
CO-3	Formulate research questions, develop hypotheses, and design appropriate research methodologies.	**8/8**	**U, Ap**	**F, C, P**	**L**	

CO-4	Analyze research results, evaluate different methods of result dissemination through research articles and proposals, and create effective strategies for communicating research findings to relevant audiences.	**2/4**	**An, E, C**	**C, P**	**L**	
CO-5	Analyze the importance of intellectual property rights (IPR) in research, evaluate the implications of different IPR strategies, and create plans to protect and manage intellectual property.	**6/1**	**An, E, C**	**F, C**	**L**	
CO-6	Understand various research methodologies used in polymer sciences, evaluate their appropriateness for different research questions, and create novel research methodologies to address specific challenges in the field	**2/8**	**U, Ap, An, E, C**	**C, P**	**L**	

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

Mapping of COs with PSOs and POs

	PSO-1	**PSO-4**	**PSO-5**	**PSO-8**	**PO-1**	**PO-2**	**PO6**	**PO-8**
CO 1		**-**	**1**		**-**	**2**	**-**	**-**
CO 2	**-**			**2**	**3**	**-**	**-**	**-**
CO 3	**-**		**-**	**2**	**-**	**-**	**-**	**3**
CO 4	**-**	**2**			**-**	**2**	**-**	**-**
CO 5	**3-**	**-**	**-**		**-**	**-**	**3**	**-**
CO 6	**-**		**-**	**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	✓			✓

Discipline	POLYMER CHEMISTRY				
Course Code	**UK7DSEPOC402**				
Course Title	Emerging Functional Polymers				
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	-	-	4hours
Pre-requisites	1. Basic knowledge about the applications of different polymers in diverse areas				
Course Summary	Emerging Functional Polymers is a course that explores the latest developments in the field of functional polymers, focusing on new materials and applications. The course covers the synthesis, characterization, properties, and applications of different functional polymers, with an emphasis on their unique functionalities and potential impact on various industries. The course will discuss cutting-edge applications of functional polymers in areas such as drug delivery, bioimaging, energy storage and sensors. Through lectures, discussions, and seminars, students will gain a comprehensive understanding of the field and be prepared to contribute to the development of future polymer technologies.				

Detailed Syllabus:

Module	Unit	Contents	Hrs
I		**Conducting Polymers (CPs)**	12
	1	Conducting Polymers-Definition and Examples; Characteristics of conducting polymers; Doping and dopants	3
	2	CPs as Semiconductors; Electrochromism and Spectroelectrochemistry of CPs	2
	3	Preparation and applications of Poly(p-phenyleneus), Poly (p-phenylenevinylenes) and polythiophenes.	2
	4	CPs based Supercapacitors, Photocatalytic applications of CPs, Biomedical and antimicrobial applications of CPs	2
	5	Recent research advancements in Conducting Polymers (*Each Student should present a minimum of one research paper as seminar)	3
II		**Advanced Biopolymers**	12
	6	Biopolymers-Classification-Natural and Synthetic, Need for biopolymers.	2
	7	Structure, sources and applications of Chitin, Chitosan, Starch, Cellulose and Cyclodextrin.	3
	8	Smart Biopolymers-pH sensitive, Thermosensitive and Stimuli Responsive systems. Applications of Smart bio polymers.	2
	9	Role of polymer in Drug Delivery-Introduction, Diffusion controlled systems, Chemically activated systems, Solvent-activated systems	2
	10	Recent research advancements in Advanced Biopolymers (*Each Student should present a minimum of one research paper as seminar)	3

III	**Polymeric Nanomaterials**		12
	11	Nanomaterials-Introduction; Polymeric Nanomaterials-Definition, Advantages over conventional nanomaterials with Examples	2
	12	Functionalization of Polymeric Materials; Polymeric NPs-Preparation-Solvent evaporation, Emulsification/solvent diffusion, Nanoprecipitation, Emulsification/reverse salting-out	3
	13	Characterisation of Polymeric NPs-Morphology, Particle Size, Zeta Potential, Dynamic Light Scattering	2
	14	Biocompatible Polymeric NPs; Bioimaging applications of Polymeric NPs	2
	15	Recent research advancements in Polymeric Nanomaterials (*Each Student should present a minimum of one research paper as seminar)	3
IV	**Porous Polymers**		12
	16	Definition, Classification of Porous Polymers- Based on Composition (organic and inorganic), Based on pore size (Micro, Meso and Macroporous)	3
	17	Covalent Organic Frameworks (COFs)- Structure, Synthesis, Applications and Examples	2
	18	Metal Organic Frameworks (MOFs)- Structure, Synthesis, Applications and Examples	2
	19	Energy and Environmental applications of Porous Polymers.	2
	20	Recent research advancements in Porous Polymers (*Each Student should present a minimum of one research paper as seminar).	3
V	**Supramolecular Polymers**		12
	21	Concepts of Supramolecular Polymerisation, Definition and Origin of Supramolecular Polymers	2
	22	Synthesis of Supramolecular Polymers- Different Methods, Self-Assembly, Gels and Hydrogels. Supramolecular Co-polymerisation	2
	23	Properties of Supramolecular Polymers- Chemical, Optical, Chiroptical, Photochemical. Applications of Supramolecular Polymers- Biological and Sensory Applications	3
	24	Naturally occuring Supramolecular Polymers-Amyloid Fibrils, Actin Filaments, Microtubules	2
	25	Recent research advancements in Supramolecular Polymers (*Each Student should present a minimum of one research paper as seminar)	3

References

1. Conducting Polymers, Fundamentals and Applications, by Prasanna. Chandrasekhar - 1999, ISBN: 9780792385646
2. Handbook of conducting polymers (1st, 2nd and 3rd Editions) ISBN: 9781574446654
3. Conducting Polymers-Chemistries, Properties and Biomedical Applications, by Ram K. Gupta, 2022, ISBN: 9781003205418
4. Biopolymers Based Advanced Materials (Volume 2) (Bio-Engineering), by Vikas Mittal, 2022, ISBN: 978-1922617279
5. Biopolymer: A Sustainable Material for Food and Medical Applications, Jaya Baranwal, 2022, DOI: 10.3390/polym14050983
6. Smart Polymers: Applications in Biotechnology and Biomedicine, Edited by Igor Galaev, Bo Mattiasson, 2007, ISBN 9780849391613

7. Polymeric Nanomaterials in Nanotherapeutics, by Cornelia Vasile, 2019, ISBN: 978-0-12-813932-5
8. Polymer Nanoparticles for Nanomedicines, Christine Vauthier, Gilles Ponchel, 2018, eBook ISBN 978-3-319-41421-8
9. Porous Polymer Science and Applications; Edited by Inamuddin, Mohd Imran Ahamed, Rajender Boddula, 2022, eBook ISBN: 9781003169604
10. Porous Polymers: Design, Synthesis and Applications, Shilun Qiu; Teng Ben, 2015, ISBN: 978-1-78262-226-0
11. Supramolecular Polymer Chemistry, by Akira Harada, 2011, ISBN:9783527323210
12. Supramolecular Polymers and Assemblies: From Synthesis to Properties and Applications, Ulrich Schubert, George R. Newkome, Andreas Winter, 2014.

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 conducting polymers and apply the knowledge gained for different applications.	**R, U, Ap**	**1**
CO-2	Apply the basic understanding about advanced biopolymers and analyse their biological applications.	**R, U, Ap, An**	**8**
CO-3	Understand the knowledge on polymeric nanomaterials and apply the theoretical concepts for proposing diverse applications	**U, Ap**	**5**
CO-4	Analyze the structure-property relationships in porous polymers and apply them for various applications	**Ap, An**	**1**
CO-5	Explore advanced topics in supramolecular polymer research and enable its effective communication	**An, E**	**8**
CO-6	Evaluate the recent research advancements in the aera of emerging functional polymers and identify the possible leads	**E, C**	**5**

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

Name of the Course: Emerging Functional Polymers Credits: 4:0:0 (Lecture:Tutorial: Practical)

CO No.	Course Outcome	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic concepts of conducting polymers and apply the knowledge gained for different applications.	**1/1**	**R, U, Ap**	**F, C**	**L**	
CO-2	Apply the basic understanding about advanced biopolymers and analyse their biological applications.	**2/8**	**R, U, Ap, An**	**F, C**	**L**	
CO-3	Understand the knowledge on polymeric nanomaterials and apply the theoretical concepts for proposing diverse applications.	**4/5**	**U, Ap**	**F, C, P**	**L**	
CO-4	Analyze the structure-property relationships in porous polymers and apply them for various applications	**2/1**	**Ap, An**	**C, P**	**L**	
CO-5	Explore advanced topics in supramolecular polymer research and enable its effective communication	**3/8**	**An, E**	**F, C,P**	**L**	
CO-6	Evaluate the recent research advancements in the aera of emerging functional polymers and identify the possible leads	**3/5**	**E, C**	**C, P**	**L**	

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

Mapping of COs with PSOs and POs:

	PSO-1	PSO-5	PSO-8	PO1	PO2	PO3	PO4
CO 1	2			2			
CO 2			2		2		
CO 3		3					1
CO 4	1				1		
CO 5			2			1	

CO 6		**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	✓	✓		✓