

INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)
(Deemed to be University Estd. u/s 3 of the UGC Act, 1956)
PALLAVARAM, THALAMBUR, PERIYAPALAYAM-CHENNAI
ACCREDITED BY NAAC WITH 'A++' GRADE

POST GRADUATE DEGREE PROGRAMME

M.Sc., Chemistry

Two Years

CURRICULUM & SYLLABUS

REGULATION 2024

Choice Based Credit System(CBCS)

&

Learning Outcomes Based Curriculum Framework(LOCF)

Effective from the Academic Year

2024 -2025

Department of Chemistry

VELS

INSTITUTE OF SCIENCE, TECHNOLOGY & ADVANCED STUDIES (VISTAS)
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DEPARTMENTOF CHEMISTRY

VISION OF THE DEPARTMENT
The Vision of the Department is to enhance our reputation as a world-class teaching and research institution reputed for its innovation, excellence and discovery, and to attract best students and staff worldwide.

MISSION OF THE DEPARTMENT	
M1	To actively promote and preserve higher values and ethics in education and research and will pursue excellence in all these areas.
M2	To undertake research in emerging areas of Chemical Sciences & Nanotechnology and transform the findings for the benefit of society.

PROGRAMME EDUCATIONAL OUTCOMES(PEO)	
PEO1	Ample opportunities in various service sectors at both national and international levels, and can work as scientists, analysts, quality controllers, academics, researchers, or establish chemical testing laboratories.
PEO2	Specialized knowledge and experience, will be capable of synthesizing, separating, analyzing, and computationally designing and developing new products.
PEO3	Engage in professional activities to enhance their own achievement and simultaneously contribute in service of humankind.
PEO4	Encourage leadership qualities in graduates with strong communication skills, mold them as good team players and managers so that they have the competence to function effectively in multi-disciplinary orientation teams.
PEO5	Academically prepared to provide feasible and sustainable solutions for real-life problems and become licensed professional chemists in due course and will contribute effectively in serving the society.

PROGRAMME OUTCOMES (PO)	
PO1	**Problem analyze:** Identify, formulate, and critically analyze chemical problems by reviewing research literature to get well-substantiated conclusions using advanced concepts and methodologies from organic, inorganic, physical, and analytical chemistry.
PO2	**Design and development of solutions: D**esign innovative solutions for complex chemical problems and design drugs, components or processes that address specified needs, incorporating appropriate considerations for public health and safety, as well as cultural, social impacts.
PO3	**Conduct investigations of complex problems: A**pply research-based knowledge to design and conduct experiments, analyze and interpret data, and synthesize information from various sources to draw valid and scientifically sound conclusions.
PO4	**Modern tool Usage**: Practice modern tools, techniques, and technologies to solve complex industrial challenges, enhancing efficiency and innovation in chemical processes and production.
PO5	**Research Attitude and Environmental Sustainability:** Develop a strong research attitude, with a focus on exploring and contributing to frontier topics in chemistry that promote environmental sustainability.
PO6	**Skilled Communicator:** Gaining knowledge in chemistry project management, efficient planning, scientific writing, and understanding ethical standards, rules, and regulations for executing scientific projects.
PO7	**Lifelong Learner:** Nurture a continuous learning mind set by encouraging the use of advanced ICT tools, as well as other resources like books and journals, to support personal academic growth and enhance employability opportunities.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO1	Global level research opportunities to pursue PhD programme and targeted approach of CSIR –NET examination.
PSO2	Design experiments, analyze, synthesize and interpret data to provide solutions to different industrial problems by working in the pure, inter and multi-disciplinary areas of chemical sciences.
PSO3	Execute new ideas in the field of research and to develop principles and techniques of science through seminars and the project.

BOARD OF STUDIES
List of Members
Department of Chemistry

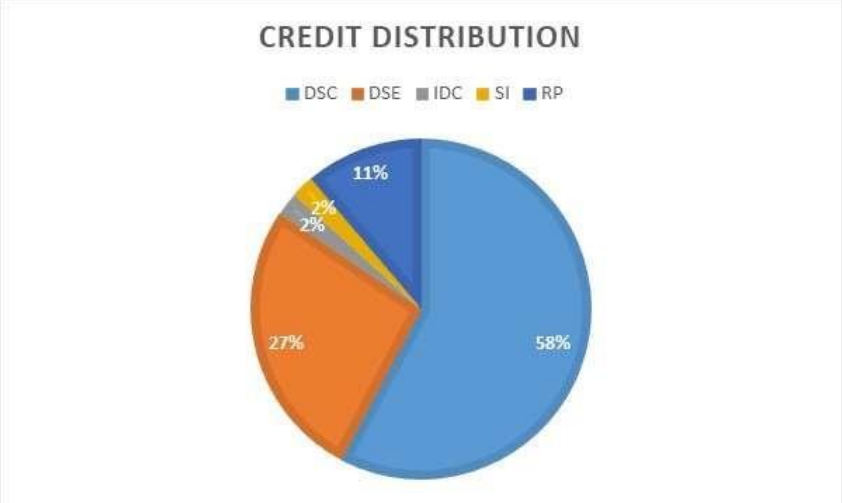
S.No	Name & Designation	Address	Role
1.	**Dr. R.A. Kalaivani** Professor & Dean	Department of Chemistry, School of Basic Sciences, VISTAS, Chennai- 600 117 Tamilnadu.Email: dean.sbs@velsuniv.ac.in Mobile: 9962506223	Chairperson (Internal Member)
2.	**Mr. Ramasamy** Head R&D	Head R&D, Sanjeev Biomedical Research Centre Kumaran Nagar,Keelkatalai, Chennai- 600 117, Tamilnadu.Email: director@sanjeevbiomed.comMobile: 9176049309	Industrial Expert (External Member)
3.	**Dr. Prabhu** Assistant Professor	Department of Physical Chemistry , University of Madras, Guindy Campus, Chennai – 600 025 Tamilnadu.Email: pprabhumu@gmail.comMobile: 9841349544	Academic Expert (External Member)
4.	**Ms. N. Vanitha** Research Associate	Research Scholar, SRM Institute ofScience Technology, Kattankulathur,Chennai 603 203, Tamilnadu. Mobile:9790790146	Alumni Member (External Member)
5.	**Dr. M.Revathi** Associate Professor & Head i/c	Department of Chemistry, VISTAS, Chennai-600 117, Tamilnadu.Email:hodchemistry@velsuniv.ac.in Mobile: 9843246060	Internal Member
6.	**Dr. K. Ramamurthy** Assistant Professor	Department of Chemistry, VISTAS, Chennai-600 117, Tamilnadu.Email: ramamurthy.sbs@vistas.ac.in Mobile: 9655024848	Internal Member
7.	**Dr. S. Deepa** Assistant Professor	Department of Chemistry, VISTAS, Chennai – 600 117, Tamilnadu.Email: sdeepa.sbs@vistas.ac.in Mobile: 8667064951	Internal Member
8.	**Dr. M. Priya** Assistant Professor	Department of Chemistry, VISTAS, Chennai – 600 117, Tamilnadu.Email: priya.sbs@vistas.ac.in Mobile: 8939318775	Internal Member

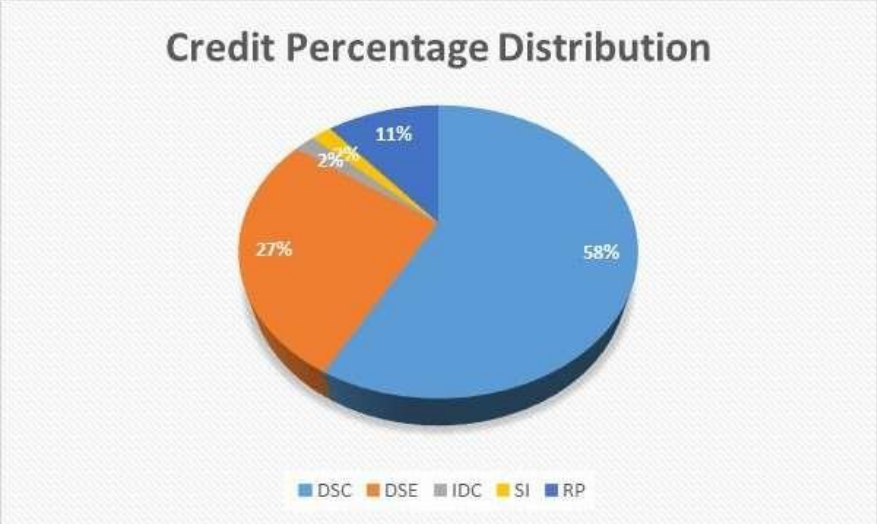
CREDIT DISTRIBUTION

M.Sc., in Chemistry

Minimum credits to be earned: 90

Component	I Sem	II Sem	III Sem	IV Sem	Total Credits
DSC	15	18	15	4	**52**
DSE/ IDC / Minor	8	4	8	4	**24**
SI	-	-	2	-	**2**
RP	-	-	-	10	**10**
GE	-	-	-	2	**2**
Total Credits	**23**	**22**	**25**	**20**	**90**





ABBREVIATIONS

DSC	Disciplinary Specific Core
DSE	Disciplinary Specific Elective
IDC	Inter disciplinary Courses
SI	Summer Internship
RP	Research Project
GE	Generic Elective

CURRICULUM STURCTURE

M.Sc., Chemistry (Two Years)

Total number of Credits: 90

	M.Sc.,Chemistry									
	Hours/Week						Maximum Marks			
SEMESTER I										
Category	**Code**	**Course**	**L**	**T**	**P**	**O**	**C**	**CIA**	**SEE**	**Total**
DSC1	24CMSG11	Organic Reaction Mechanism and Stereochemistry	4	0	0	2	4	40	60	100
DSC2	24CMSG12	Concepts of Inorganic Chemistry	4	0	0	2	4	40	60	100
DSC3	24CMSG13	Advanced thermodynamics and kinetics	4	0	0	2	4	40	60	100
DSE1/ IDC1/ Minor1		DSE 1	4	0	0	2	4	40	60	100
DSE2/ IDC2/ Minor2		DSE 2	4	0	0	2	4	40	60	100
DSC1	24PMSG11	Organic Chemistry Practical-Practical I	0	0	6	1	3	40	60	100
			20	**-**	**6**	**-**	**23**	**-**	**-**	**-**

CIA- Continuous Internal Assessment SEE - Semester End Examination

***L– Lecture,* T-Tutorial, *P- Practical, *O- Outside the class effort/ self-study**

SEMESTER II										
Category	**Code**	**Course**	**L**	**T**	**P**	**O**	**C**	**CIA**	**SEE**	**Total**
DSC4	24CMSG21	Organic chemistry and Molecular rearrangement	4	0	0	2	4	40	60	100
DSC5	24CMSG22	Coordination Chemistry	4	0	0	2	4	40	60	100
DSC6	24CMSG23	Quantum Chemistry & group theory	4	0	0	2	4	40	60	100
DSE3/ IDC3/ Minor3		DSE -3	4	0	0	2	4	40	60	100
DSC2	24PMSG21	Inorganic Chemistry Practical-Practical II	0	0	6	1	3	40	60	100
DSC3	24PMSG22	Physical Chemistry Practical-Practical III	0	0	6	1	3	40	60	100
			16	**-**	**12**	**-**	**22**	**-**	**-**	**-**

SEMESTER III										
Category	**Code**	**Course**	**L**	**T**	**P**	**O**	**C**	**CIA**	**SEE**	**Total**
DSC7	24CMSG31	Organic photochemistry and Pericyclic reaction	4	0	0	2	4	40	60	100
DSC8	24CMSG32	Solid State Chemistry	4	0	0	2	4	40	60	100
DSC9	24CMSG33	Electrochemistry: Fundamentals and Its Applications	4	0	0	2	4	40	60	100
DSE4/ IDC4/ Minor4		DSE-4	4	0	0	2	4	40	60	100
DSE5/ IDC5/ Minor5		DSE-5	4	0	0	2	4	40	60	100
DSC4	24PMSG31	Analytical Chemistry Practical - Practical IV	0	0	6	1	3	40	60	100
SI	24IMSG31	Internship	0	0	4	1	2	-	100	100
			20	**-**	**10**	**-**	**25**	**-**	**-**	**-**

SEMESTER IV										
Category	**Code**	**Course**	**L**	**T**	**P**	**O**	**C**	**CIA**	**SEE**	**Total**
DSC10	24CMSG41	Electroanalytical and Separation Techniques	4	0	0	2	4	40	60	100
DSE 6 / IDC6 / Minor6		DSE-6	4	0	0	2	4	40	60	100
GE		DSE/IDC-1	2	0	0	1	2	40	60	100
RP	24RMSG41	Research Project	-	-	20	-	10	40	60	100
			10	**-**	**20**	**-**	**20**	-	-	-
		Overall Total	**66**	**0**	**48**		**90**			

DISCIPLINESPECIFICCORECOURSES

Category	Code	Course	L	T	P	O	C
DSC 1	24CMSG11	Organic Reaction Mechanism and Stereochemistry	4	0	0	2	4
DSC 2	24CMSG12	Concepts in Inorganic Chemistry	4	0	0	2	4
DSC3	24CMSG13	Advanced thermodynamics and kinetics	4	0	0	2	4
DSC 1 (Practical)	24PMSG11	Organic Chemistry Practical-Practical I	0	0	6	1	3
DSC 4	24CMSG21	Organic Chemistry and Molecular rearrangement	4	0	0	2	4
DSC 5	24CMSG22	Coordination Chemistry	4	0	0	2	4
DSC 6	24CMSG23	Quantum Chemistry &Group theory	4	0	0	2	4
DSC 2 (Practical)	24PMSG21	Inorganic Chemistry Practical-Practical II	0	0	6	1	3
DSC3 (Practical)	24PMSG22	Physical Chemistry Practical-Practical III	0	0	6	1	3
DSC 7	24CMSG31	Organic photochemistry and Pericyclic reaction	4	0	0	2	4
DSC 8	24CMSG32	Solid State Chemistry	4	0	0	2	4
DSC 9	24CMSG33	Electrochemistry : Fundamentals and Its Applications	4	0	0	2	4
DSC 4 (Practical)	24PMSG31	Analytical Chemistry Practical - Practical IV	0	0	6	1	3
DSC 10	24CMSG41	Electroanalytical and Separation Techniques	4	0	0	2	4

DISCIPLINE SPECIFIC ELECTIVE COURSES

Category	Code	Course	L	T	P	O	C
DSE 1		Nuclear and Photochemistry	4	0	0	2	4
DSE 2		Spectroscopic Methods	4	0	0	2	4
DSE 3		Chemistry of Natural Products	4	0	0	2	4
DSE 4		Macromolecular Chemistry	4	0	0	2	4
DSE 5		Numeric Methods for Computational Chemistry	4	0	0	2	4
DSE 6		Bio – Inorganic Chemistry	4	0	0	2	4
DSE 7		Strategic Management of Pharma Industry	4	0	0	2	4
DSE 8		Medicinal Chemistry	4	0	0	2	4
DSE 9		Experimental Methods in Chemistry	4	0	0	2	4
DSE 10		Functional Organic Materials	4	0	0	2	4
DSE 11		Surface Chemistry and Catalysis	4	0	0	2	4
DSE 12		Organometallic Chemistry	4	0	0	2	4
DSE 13		Nanomaterials	4	0	0	2	4
DSE 14		Forensic Science	4	0	0	2	4
IDC 1		Materials Science	2	0	0	1	2
IDC 2		Chemistry of Consumer Products	2	0	0	1	2

SUMMER INTERNSHIP

Category	Code	Course	L	T	P	O	C
SI	24IMSG31	Internship	0	0	4	1	2

RESEARCH PROJECT

Category	Code	Course	L	T	P	O	C
RP	24RMSG41	Research Project	-	-	20	-	10

SEMESTER I

24CMSG11 ORGANIC REACTION MECHANISM AND STEREOCHEMISTRY

L	T	P	O	C
4	0	0	2	4

Course Objectives:

- To understand the mechanism of various types of organic reactions and heterocyclic compounds.
- To correlate the principles of substitution, elimination addition reactions and heterocyclic compounds.
- To design new routes to synthesis organic and heterocyclic compounds.

UNIT – I Principles of Structure and Reactivity 12

Review of basic principles of structure and bonding, hybridization, conjugation, Important properties of organic molecules: dipole moments, inductive effect (+I, -I), mesomeric effect, resonance effect, steric effect, aromaticity and anti-aromaticity, Huckel's rule, y-aromaticity, homo-aromaticity, neutral and charged aromatic systems (3, 4, 5, and 7- membered ring systems), annulenes and fused rings systems, heteroannulenes, aromaticity of heterocycles.

UNIT – II Stereochemistry 12

Stereochemistry: conformational analysis of acyclic and cyclic systems, effect of conformation on reactivity, elements of symmetry, chirality, molecules with more than one chiral center, projection formulae (i) Fischer (ii) Sawhorse (iii) Newman (iv) Flying Wedge, methods of resolution, specific rotation, optical purity and enantiomeric excess, and stereoselective reactions, optical activity in the absence of chiral carbon.

UNIT – III Nucleophilic Additions to Carbonyl Compounds 12

Nucleophilic addition to carbonyl compounds, Claisen-Schmidt condensation, directed aldol condensations, Claisen ester condensation, Dieckmann reaction, Stobbe condensations, Knoevenagel condensations, 1,4-conjugate additions (Michael addition), Robinson annulation, Wittig reactions, Mannich reactions.

UNIT – IV Aliphatic and Aromatic Nucleophilic Substitution 12

Nucleophilic substitution reactions, SN^1, SN^2, SN^i and neighbouring group mechanisms, nucleophilic substitutions at allylic, aliphatic and vinyl carbons, effect of substrate, nucleophile, leaving group, and medium, stereochemistry of nucleophilic substitution, ambident nucleophiles, aromatic nucleophilic substitutions, S_NAr, S_N1 and benzyne mechanisms, Sommelet-Hauser, Von Ritcher and Smiles rearrangement, Bucherer and Rosenmund reactions.

UNIT – V Aromatic and Aliphatic Electrophilic Substitution **12**

Aromatic electrophilic substitution, the effect of leaving group, Friedel-Crafts alkylation, acylation and arylation, aliphatic substitution mechanisms, SE_2, SE_i and SE_1, addition-elimination and cyclic mechanisms, halogenations of ketones, aldehydes and carboxylic acids, aliphatic diazonium coupling, sulphonation, sulphenylation, acylation, Stork enamines, carbene and nitrene insertions, Kolbe-Schmidt reaction.

TOTAL: 60 hrs

Text Books:

1. D. Nasipuri, "Stereochemistry of Organic Compounds: Principles and Applications," New Age International Private Limited, 2021..
2. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 8th Edition, Wiley, 2019.
3. Jonathan Clayden, Nick Greeves, and Stuart Warren, Organic Chemistry, 2nd Edition, Oxford University Press, 2012.

Reference Books:

1. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 9th Edition, Wiley, 2025
2. Francis A. Carey and Richard J. Sundberg, *Advanced Organic Chemistry*, 5th Edition, Springer, 2007
3. Jonathan Clayden, Nick Greeves, Stuart Warren, and Peter Wothers, *Organic Chemistry*, 2nd Edition, Oxford University Press, 2012.

Web Sources:

1. https://archive.nptel.ac.in/courses/104/101/104101005/
2. https://www.organic-chemistry.org/
3. https://www.clutchprep.com/organic-chemistry

Course Outcomes (CO): At the end of this course, learners will be able to,

CO1:	Outline the concept of aromaticity in benzenoid, non-benzenoid and heterocyclic compounds.	**K2**
CO2:	Classify the various mechanism involved in various types of organic reactions with evidences.	**K2**
CO3:	Understand the applications of synthetically important reagents.	**K3**
CO4:	Compare the reactivity between aliphatic and aromatic compounds.	**K4**
CO5:	Explain the synthetic routes for organic and heterocyclic compounds	**K2**
CO6	Outline the principles aromatic nucleophilic substitution reaction	**K2**
CO7	Analyse and apply the different kind of intermediate in aromatic and aliphatic substitution reaction	**K4**

Mapping of Program outcomes with course outcomes:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	2	-	-	2	3	2
CO2	3	3	3	3	3	-	-	2	3	3
CO3	3	3	3	2	3	-	2	3	2	2
CO4	3	3	3	3	2	2	-	2	2	3
CO5	3	3	2	2	3	2	2	3	2	2
CO6	3	3	2	2	3	2	-	3	2	2
CO7	3	3	2	2	3	-	2	3	2	2
Average	**3**	**3**	**2.6**	**2.4**	**2.6**	**2**	**2**	**2.4**	**2.4**	**2.4**

Assessment Methods:

CAT1	**CAT2**	**Model Exam**	**End Semester Exams**	**Assignments**
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**

24CMSG12 CONCEPTS OF INORGANIC CHEMISTRY

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To understand the different kinds of chemical forces in molecules.
- To identify the nature of chemical bond in a given inorganic compound.
- To predict the nature and topology of inorganic compounds.

UNIT - 1: Atomic Structure and Periodic Table 12

Modern views on atomic structure: wave mechanical description of electron and orbitals, radial density functions and orbital energies, angular functions and orbital shapes. Effective nuclear charge - Slater rule and their uses: computation of and radii of atoms and ions. Modern periodic table: periodic properties, trends and the underlying reasons.

UNIT-2: Chemical Bonding 12

Hybridization: Derivation of wave functions for the following orbital hybridisation types: sp (BeH_2); sp^2 (BF_3); sp^3 (CH_4) considering only sigma bonding. Molecular Orbital Theory (LCAO-MO approach) for Electron deficient and Electron rich species. Molecular topologies: shared and lone pairs and Lewis structures, hybridization and geometry, VSEPR model, and Bent's rule. Recapitulation of hard soft acids and bases (HSAB) principle, Acid-bas strength and softness and hardness; Super acids and bases.

UNIT - 3: Crystallography 12

Principles: Miller indices, crystal lattices, and UNIT cells. X-ray diffraction: Bragg's law, powder method, single crystal diffraction, structure factor, and Fourier synthesis. Structure of sodium chloride, cesium chloride, fluorite, antifluorite, zinc blende, wurtzite, rutile, spinels, inverse spinels, and perovskite. Electron and neutron diffraction: basic principles and typical applications

UNIT-4: Organometallic Chemistry 12

Recapitulation of classification of organometallic compounds, electron counting and eighteen electron rules, Sixteen electron rule, Synthesis, structure and bonding of the following organometallic compounds: Alkyl and Aryl derivatives, Carbenes and Carbynes, Alkene complexes, Alkyne complexes, Allyl complexes, Cyclopentadiene complexes and Arene complexes (sandwich and half sandwich complexes).

UNIT-5: Bioinorganic Chemistry 12

Role of metal ions in biological processes, structure and properties of metalloproteins in electron transport processes, cytochromes, ferrodoxins and iron sulphur proteins, ion transport across membranes, Biological nitrogen fixation, PS-I, PS – II, Oxygen uptake proteins.

TOTAL: 60 hrs

Text Books:

J. H. Huheey, E. A. Keiter, and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 5th Edition, Pearson Education, 2014.

D. Banerjea, Coordination Chemistry, 4th Edition, Tata McGraw-Hill Education, 2012.

A. F. Wells, Structural Inorganic Chemistry, 6th Edition, Oxford University Press, 2016.

Reference Books:

1. Chakraburty, Soild State Chemistry, New Age International
2. G. L. Eichhron, Inorganic Biochemistry, Vol I and II, Elesevier
3. Progress Inorganic chemistry, Vol 18 and 38, J. J. Loppard, Wiley

Web Sources:

1. *https://onlinecourses.nptel.ac.in/noc22_cy02/preview*
2. *https://nptel.ac.in/courses/104101121*

Course Outcomes (CO): At the end of this course, learners will be able to

CO1:	Outline the basic principles of inorganic chemistry.	**K2**
CO2:	Understand the role of inorganic chemistry as it is related to the other areas of the discipline such as biochemistry, analytical, physical, etc.	**K2**
CO3:	Prove the theoretical problems and be able to apply the solutions to practical problems.	**K5**
CO4:	Analyse the crystalline structure of inorganic compounds	**K4**
CO5:	Explain the classification of organometallic compounds	**K5**
CO6	Outline the principles and synthesis of organometallic compounds	**K2**
CO7	Analyse and apply biological process of metalloproteins	**K4**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	2	3	3	2	2	-	-	2	3	3
CO2	3	3	3	3	3	2	2	2	3	3
CO3	3	3	3	2	3	2	2	2	3	3
CO4	3	3	3	3	2	2	-	2	3	3
CO5	2	3	3	2	3	2	-	3	2	2
CO6	3	3	3	2	3	-	-	2	3	3
CO7	3	3	3	3	2	2	2	2	3	3
Average	**2.6**	**3**	**3**	**2.4**	**2.6**	**2**	**2**	**2.2**	**2.8**	**2.8**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**

24CMSG13 **ADVANCED THERMODYNAMICS AND KINETICS**

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To know quantum chemistry and classical thermodynamics in the evaluation of macroscopic properties.
- To understand the inter linking of quantum chemistry and statistical thermodynamics that leads to classical thermodynamics.
- To apply the concepts of statistical thermodynamics for the study of equilibrium reactions and reaction rates.

UNIT:1 Classical Thermodynamics 12

Review of laws of thermodynamics- Carnot cycle, Efficiency of heat engine, Entropy, entropy calculations – Free energy, criteria for spontaneity, Free energy as function of Temperature and Pressure. Chemical potential – Fugacity, determination of fugacity - Activity coefficient –partial molar quantities, partial molar volume, chemical potential, Gibbs-Duhem equation, experimental absolute entropies, determination, exceptions to third law, unattainability of absolute zero.

UNIT-II Irreversible Thermodynamics 12

Thermodynamic functions in terms of the partition function, internal energy, entropy, Helmholtz function, pressure, Gibbs function, residual entropy, equilibrium constant, isotope effects, average energies and equipartition principle, heat capacity of monoatomic gases, population inversion, negative Kelvin temperature, Einstein's and Debye's theories of heat capacities of solids, statistical basis of entropy of H_2 gas, ortho and para nuclear states, calculation of entropy in terms of ortho- para ratio, residual entropy of H_2 at 0 K.

UNIT – III Statistical Thermodynamics 12

Macro and micro states, ensembles (microcanonical and canonical), Maxwell Boltzmann statistics, Boltzmann- Planck equation, Fermi-Dirac and Bose-Einstein statistics, Comparison of three of statistics, negative absolute temperatures, partition function, evaluation of the partition function translational partition function, rotational partition function, vibrational partition function, electronic partition and nuclear partition function.

UNIT-IV Chemical Kinetics 12

Empirical Rate Laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants - Lindemann and Rice-Ramsperger- Kassel (RRK); unimolecular reactions; Kinetics of parallel – opposing reactions - chain reactions (hydrogen-halogen reactions). Catalysis-Homogeneous catalysis-heterogeneous catalysis-enzyme catalysis-Michaelis-Menton kinetics, - Autocatalysis.

UNIT V: Chemical and Phase Equilibria 12

Thermodynamic derivation of equilibrium constant K for reaction involving ideal and real gases – Thermodynamics of chemical reactions (reaction potential), Principal of Lechatlier – and Braun – chemical equilibria. Standard reaction free energy – free energy calculation from thermodynamical. Gibbs phase rule – its thermodynamic derivation application of phase rule to three component systems. Formation of one pair, two pairs and three pairs of partially miscible liquids – systems composed of two solids and a liquid.

Total 60 hrs

Text Books:

1. Rajaram and J.C. Kuriakose, Thermodynamics for Students of Chemistry, 3rd Edition, S. Chand & Co., 2016.

2. I.M. Klotz and R.M. Rosenberg, Chemical Thermodynamics, 8th Edition, W.A. Benjamin Publishers, 2013.

3. M.C. Gupta, Statistical Thermodynamics, 2nd Edition, New Age International Publishers, 2015.

Reference Books:

1. P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, 2018, International 11th Edition, Oxford University Press, UNITed Kingdom.

2. Ira N. Levine, Quantum Chemistry, 7 th Edition, 2014, Pearson Prentice Hall, London.

3.K. J. Laidler, Chemical Kinetics, 1987, 3 rd Edition, Harper & Row, New York.

Web Sources:

1. *https://nptel.ac.in/courses/104/103/104103112/*
2. *https://bit.ly/3tL3GdN*
3. *https://bit.ly/39IWesL*

Course Outcomes (CO): At the end of this course, learners will be able to

CO1:	Outline the basic principles of thermodynamic properties of ideal and real gases of a system.	**K2**
CO2:	Understand the student with the fundamental concepts of Irreversible thermodynamics	**K2**
CO3:	Classify the basic principles of statistical thermodynamics	**K4**
CO4:	Analyse kinetics of chain reactions using different theories of reaction rates	**K4**
CO5:	Understand the concepts of Chemical and Phase Equilibria.	**K2**
CO6	Outline the various principle and mechanism of collision theory	**K2**
CO7	Analyse and apply various reaction mechanism in chemical equilibira	**K4**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	2	3	3
CO2	3	3	3	3	3	2	2	2	3	3
CO3	3	3	3	2	3	-	-	3	2	2
CO4	3	3	3	2	2	2	2	2	2	2
CO5	3	2	3	2	3	-	-	3	2	2
CO6	3	3	3	2	2	-	-	2	2	2
CO7	3	2	3	2	3	2	2	3	2	2
Average	**3**	**2.6**	**3**	**2.6**	**2.6**	**2**	**2**	**2.4**	**2.4**	**2.4**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**

24PMSG11 **Organic Chemistry Practical - Practical I**

L	T	P	O	C
0	0	6	1	3

Course Objective:

- To know the techniques of separating organic compounds from the mixture.
- To learn the methods of crystallization and the method of purification.
- To provide practical experience in conducting organic reactions, understanding their mechanisms, and predicting the outcomes based on theoretical knowledge.

I. Identification of components in a two-component mixture and preparation of their derivatives.

1. Acid Substance and Neutral Substance
2. Basic Substance and Neutral Substance
3. Phenolic Substance and Neutral Substance
4. Acid Substance and Phenolic Substance
5. Phenolic Substance and Basic Substance

II. Determination of b.pt. /m.pt. for components and m.pt. for the derivatives.

III. Preparations:

1. p-Nitrobenzoic Acid from p-Nitrotoluene
2. Anthraquinone from Anthracene
3. Benzhydryl from Benzophenone
4. m-Nitroaniline from m-dinitrobenzene
5. 1,2,3,4-Tetrahydrocarbazole from Cyclohexanone
6. Methyl orange from Sulphanilic acid.
7. Iodobenzene from Aniline

TOTAL: 30hrs

Text Books:

1. N.S. Gnanapragasam, G. Ramamurthy, Organic Chemistry Lab Manual, 2nd Edition, S. Vishwanath Printers & Publishers Pvt. Ltd, Chennai, 2018.
2. Douglas A. Skoog, Donald M. West, F. James Holler, and Stanley R. Crouch, Fundamentals of Analytical Chemistry, 9th Edition, Cengage Learning, 2014.
3. J. Mendham, R.C. Denney, J.D. Barnes, and M.J.K. Thomas, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Pearson Education, 2009

.***Reference Books:***

1. A.I. Vogel, *Vogel's Textbook of Practical Organic Chemistry*, 7th Edition, Pearson Education, 2012.
2. J Leonard, B Lygo, G Procter, Advanced Practical Organic Chemistry, Stanley Thornes (Publishers) Ltd. 1st Indian Edition, 2004.
3. Leonard, John, Barry Lygo, and Garry Procter. *Advanced practical organic chemistry*. CRC press, 2013.

Web Sources:

1. https://www.masterorganicchemistry.com/
2. https://www.chemistryhelpcenter.org/organic-chemistry-resources/
3. Master Organic Chemistry - An Online Organic Chemistry Resource

Course outcomes: At the end of this course, learners will be able to:

CO1	Demonstrate the solubility nature of organic substances of different functional group.	**K2**
CO2	Learn the pilot separation of bi mixtures.	**K1**
CO3	Explain the systematic procedure organic substances analysis	**K4**
CO4	Learn two stage preparation involving molecular rearrangement oxidation.	**K1**
CO5	Test for the preparation involving nitration and bromination reaction	**K4**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	2	3	3	3
CO2	3	3	3	3	3	-	-	3	3	3
CO3	3	3	3	2	3	-	2	3	3	3
CO4	3	3	3	3	2	2	2	2	3	3
CO5	2	3	3	3	3	-	-	3	2	2
Average	**2.8**	**2.8**	**3**	**2.6**	**2.6**	**2**	**2**	**2.8**	**2.8**	**2.8**

Assessment Methods:

CAT1	**CAT2**	**Model Exam**	**End Semester Exams**	**Assignments**
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/Presentation**
			✓	✓

SEMESTER II

24CMSG21 ORGANIC CHEMISTRY AND MOLECULAR REARRANGEMENT

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To study mechanisms of addition reactions, elimination reactions, oxidation and reduction reactions and reactions involving rearrangements.
- To understand the conformation of some important organic compounds.
- To understand potential rearrangements, chemists can predict the products of organic reactions.

UNIT–I Addition to carbon-carbon and carbon-hetero multiple bonds 12

Electrophilic, nucleophilic and neighbouring group participation mechanism-Addition of halogen and nitrosyl chloride to olefins. Hydration of olefins and acetylenes. Hydroboration, Hydroxylation, Michael addition, Robinson annulation reaction DielsAlderreaction,1,3-dipolar additions.Umpolung reactions and their application in organic synthesis.Carbenes and their addition to double bonds-Simmon Smith reaction, Mannich, Stobbe, Darzen, Wittig, Wittig – Horner, Tebbe and Benzoin reactions.

UNIT–II Elimination Reactions 12

E1, E2 and E1cB mechanism- E1, E2 and E1cB Spectrum—orientation of the double bond – Hoffmann and Saytzeffrules-competition. Typical elimination reactions – dehydration, dehydrohalogenation and dehalogenation. Stereochemistry of E2 eliminations in cyclohexane systems. Mechanism of pyrolytic elimination. Chugaev and Cope eliminations.

UNIT–III Molecular Rearrangements 12

A detailed study with suitable examples of the mechanism of the following rearrangements: Pinacol-pinacolone-Wagner Meerwein, Demjanov, dienone–phenone, Favorskii, Lossen, Baeyer–Villiger, Dakin Rearrangement, Wiitig,Hoffman-curtius, Beckmann rearrangements.

UNIT–IV Oxidation and Reduction 12

Mechanisms – study of the following oxidation reactions–oxidation of alcohols using chromium (Jones oxidation, Collins & Sarrettreagents, PCC&PDC) -use of DMS(Corey-Kim Oxidation), DMSO in oxidizing alcohols- Dess-Martin Oxidation- oxidation of alkene to carbonyl (OsO_4, $Pb(OAc)_4$,Ozonolysis) , SeO_2 and Sharpless Asymmetric epoxidatron. Reductions: selectivity in reduction of 4-T- Butyl cyclohexanone using select rides hydride reductions – synthetic importance of Clemmenson and Wolff- Kishner reductions- modifications of Wolff-Kishner reduction – Birch reduction, MPV reduction and Rosemand reduction.

UNIT–V Conformational Analysis 12

Conformation of some simple 1,2 disubstituted ethane derivatives. Conformational analysis of disubstituted cyclohexanes and their stereochemical features (geometric and optical isomerism by these derivatives). Conformation and reactivity of substituted cyclohexanols (oxidation and acylation), cyclohexanones (reduction) and cyclohexane-Application of conformational analysis. Analytical technique in Conformational analysis.

TOTAL: 60 hrs

Text Books:

1. R.O.C. Norman, Principles of Organic Synthesis, 3rd Edition, Chapman and Hall/CRC, 2017.
2. Francis A. Carey, Richard J. Sundberg, Advanced Organic Chemistry: Part B Reactions and Synthesis, 5th Edition, Springer, 2007.
3. Richard O.C. Norman, James M. Coxon, Principles of Organic Synthesis, 3rd Edition, CRC Press, 2014.

Reference Books:

1. S.M. Mukherji and S.P. Singh, Organic Reaction Mechanism, 4th Edition, Macmillan India Ltd., 2015.
2. P.S. Kalsi, Textbook of Organic Chemistry, 3rd Edition, Wiley Eastern Ltd., 2017.
3. Thomas Laue, Andreas Plagens, Named Organic Reactions, 3rd Edition, Wiley-VCH, 2017.

Web Sources:

1. Molecular Rearrangements in Organic Synthesis | Wiley Online Books
2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_I_
3. mjdgandcagmikhlbjnilkmfnjeamfikk/https://www.chem.iitb.ac.in/~kpk/ra.pdf

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	Learn the principle of addition reaction	**K2**
CO2:	Discuss the mechanism of familiar organic name reactions followed by addition mechanism	**K3**
CO3:	Learn the concepts of elimination reaction	**K2**
CO4:	Understand the detail mechanism of various types of molecular rearrangement	**K2**
CO5:	Interpret the various familiar oxidation reactions like oppenaur oxidation	**K2**
CO6	Understand the concept of different oxidation and reduction reagent in organic synthesis	**K2**
CO7	Summarize the concept of stereochemistry in di-substituted cyclo hydrocarbons	**K4**

Mapping of Program outcomes with course outcomes

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	2	2	-	2	3	3
CO2	3	3	3	-	2	2	2	3	3	3
CO3	3	3	3	2	-	2	-	2	2	2
CO4	3	2	3	3	2	-	2	3	2	2
CO5	3	3	3	2	-	2	-	2	2	2
CO6	3	2	3	3	2	2	-	3	2	2
CO7	3	2	3	-	3	-	2	2	2	2
Average	**3**	**2.4**	**3**	**2.33**	**2.25**	**2**	**2**	**2.2**	**2.4**	**2.4**

Assessment Methods

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

24CMSG22 **COORDINATION CHEMISTRY**

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To learn about coordination chemistry, nomenclature and various theories, Werner Theory, valence bond theory, crystal field theory, Magnetic properties and splitting.
- To learn about reaction mechanism and f block elements.
- To explore the electronic properties of coordination complexes and their reactivity, including their roles in catalysis, redox reactions.

UNIT – I Coordination Chemistry 12

Introduction: Werner‘s theory and Sidgwick theory, EAN and formation of metal-metal bond in dimers, stability of complexes, determination of stability constants, Jobs method, stepwise stability constant, overall stability constant, factors affecting stability of coordination compounds, charge and size of central metal ion, chelate ring size, steric effects. Isomerism: linkage, ionization, hydrate, coordination, coordination position isomerism, geometrical and optical isomerism.

UNIT – II Theories of Coordination Chemistry 12

Valence bond theory hybridization, geometry, magnetism, drawbacks of VBT. Crystal field theory: crystal field effects, crystal field splitting in octahedral and tetrahedral geometries, high-spin and low-spin complexes, spectrochemical series, Jahn-Teller theorem, covalency in transition metal complexes, intensity of d-d transitions, spin-spin splitting, hyperfine splitting, MO Theory: metal orbitals and LGOs suitable for σ and π bonding in octahedral geometry, construction of qualitative MO energy level diagram for bonding in octahedral geometry.

UNIT – III Magnetic Properties and Splitting 12

Magnetic properties of tetrahedral and octahedral complexes-Gouy’s method, anomalous magnetic moment, thermal effects, spin and orbital contribution quenching, spin cross over rule, term symbols for equivalent and nonequivalent electrons, p2 - d2splitting of terms in square planar, tetrahedral, octahedral fields, Orgel (d1 to Sd9 octahedral and tetrahedral complexes) and Tanabe Sugano diagrams(d1,d6 complexes and its applications), charge transition spectra of metal complexes.

UNIT – IV Reaction and Mechanism in Coordination chemistry 12

Ligand substitution reactions in octahedral, square planar complexes, labile and inert complexes (application of VBT, MOT), mechanism in Coordination chemistry, theories of trans effect and its application, Electron transfer reactions, inner sphere mechanism, outer sphere mechanism, Marcustheory and its applications, complementary and non - complementary electron transfer reactions, synthesis of coordination compounds using electron transfer reactions, metal assisted reactions, aldol condensation, ester hydrolysis.

UNIT – V Lanthanides and Actinides 12

Lanthanide and actinide series: Abundance and natural isotopes, occurrence, oxidation states, lanthanide contraction, similarity in properties,chemical properties of Ln(III)cations, magnetic properties, colour and electronic spectra of lanthanide compounds, separation of lanthanides, solvent extraction, ion exchange, chemical properties of Ln(III) metal ions, uranium-occurrence, metallurgy; chemical properties of hydrides, oxides, and halides, complexes of lanthanides and actinides.

Total: 60 hrs.

Text Books

1. Puri B. R., Sharma L. R., Kalia K. K., Principles of Inorganic Chemistry, 38th Edition, Milestone Publishers, 2021.
2. William W. Porterfield, Inorganic Chemistry, 2nd Edition, Academic Press, 2019.
3. F. A. Cotton, G. Wilkinson, P. L. Gaus, Basic Inorganic Chemistry, 6th Edition, John Wiley & Sons, 2019.

Reference Books:

1. R. D. Madhan, "Modern Inorgnaic Chemistry" S. Chand & Co., 6th edition, **2012**
2. James E. Huheey, Ellen, A. Keiter, Richard, L. Keiter, "Inorganic Chemistry" Pearson education (Singapore Pvt Limited) 9th edition, **2013.**
3. J. D.Lee, Concise Inorganic chemistry" Blackwell Science Limited (France) 9th edition, 2013

Web Sources:

1. https://www.tutorialsduniya.com/notes/coordination-chemistry-lecture-notes-pdf/
2. https://www.alchemyst.co.uk/pdf/Inorganic/coordination_chem.pdf
3. Concise Inorganic Chemistry, 5th Ed - J. D. Lee - Google Books

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	Learn the terms like covalence in transition metal complexes, spin states, hybridization, geometry, magnetism, and crystal field effects.	**K2**
CO2:	Understands the concepts behind coordination chemistry theories, including molecular orbital (MO) theory, Sidgwick theory, valence bond theory (VBT), crystal field theory (CFT), and Werner's theory	**K2**
CO3:	Analysis and differentiate between para-, dia-, ferro-, and antiferromagnetism magnetic properties of coordination complexes.	**K4**
CO4:	Understand how coordination compounds undergo ligand substitution, hydrolysis, a nation, and electron transfer reactions.	**K2**
CO5:	Describe the different theories, reaction and mechanism of coordination compounds.	**K4**
CO6	Understanding the abundance, analysis and preparation of lanthanide compounds	**K2**
CO7	Explain the abundance, analysis and preparation of actinide compounds	**K2**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	**PO6**	**PO7**	PSO1	PSO2	PSO3
CO1	3	-	3	2	2	2	-	2	3	3
CO2	3	3	3	-	2	2	-	3	3	3
CO3	1	3	3	2	-	2	2	2	2	2
CO4	3	-	3	3	2	2	-	2	2	2
CO5	3	2	2	-	3	-	2	2	2	2
CO6	3	2	2	-	3	2	-	2	2	2
CO7	3	2	2	-	3	2	-	2	2	2
Average	2.8	2.66	2.8	2.33	2.25	2	2	2.14	2.4	2.4

Assessment Methods:

CAT1	**CAT2**	**Model Exam**	**End Semester Exams**	**Assignments**
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

VES
KNOWLEDGE IS POWER

L	T	P	O	C
4	0	0	2	4

24CMSG23 **QUANTUM CHEMISTRY & GROUP THEORY**

Course Objective:

- To study fundamental aspects of classical mechanics, the harmonic oscillator, rigid rotor and Born –Oppenheimer approximation.
- To learn about the general aspects of group theory.
- To understand complex chemical phenomena and enhance their ability to conduct research in the field.

UNIT–I Quantum Chemistry-I **12**

Classical mechanics-reason for failure-Basic principles of quantum mechanics. Atomic spectra, block body radiation, photoelectric effect-, Bohr's correspondence principle-De Broglie wave particle duality- Heisenberg uncertainty principle. Operator algebra, Linear and Hermitian operators. Eigen Values and Eigen Functions. Quantum mechanical postulates– Schrodinger equation–elementary applications of Schrodinger's equation–the particle in a box.

UNIT–II Quantum Chemistry-II **12**

The harmonic oscillator – the rigid rotor- the hydrogen atom – Schrodinger equation for hydrogen atom –unnormalised and normalised wave equations-the solution- the origin of quantum numbers (Angular momentum and spin)-their physical significance. Helium atom and Pauli's exclusion principle.

UNIT–III Quantum Chemistry-III **12**

Approximation methods –Variation and Perturbation theorem, methods – application to hydrogen, helium atoms – R, S Coupling and term symbols for atoms. Born-Oppenheimer approximation – valence bond theory for hydrogen molecule –LCAO-MO theory for di and poly atomic molecules-concept of hybridization –Huckel theory for conjugated molecules (ethylene, butadiene and benzene) – semi-empirical methods-Slater orbital and HF-SCF methods.

UNIT–IV Group theory-I **12**

Symmetry elements and symmetry operations – concept of Group and its properties, Group multiplication tables- Mathematical rules for the formation of a group, - Definition and classification of Point groups – Identification and determination – Matrix representations- Reducible and irreducible representations- Similarity transformation– Character table- Construction of Character table for C_{2V} and C_{3V} point group- Orthogonality theorem and its consequences- Mülliken symbols, reduction formula. Determination of symmetry of hybrid orbitals

UNIT–V Group theory-II **12**

Determination of symmetry of hybrid orbitals-Symmetry of hybrid orbitals in non-linear molecules (H_2O,CH_4, XeF_4, BF_3,$SF_6$and NH_3). Molecular vibrations- symmetry aspects of molecular vibrations -Direct product representation-Determination – IR and Raman activity of vibrational mode sinnon-linear molecules. Symmetry selection rules of infrared and Raman Spectra. Selection rules for electronic transitions. Symmetry of molecular orbitals and electronic states of HCHO. Selection rules for electronic transitions of HCHO. **Total: 60hrs**

Text Books:

1. R. Anantharaman, Fundamentals of Quantum Chemistry, 2nd Edition, Macmillan India Limited, 2018.
2. M.S. Ramakrishnan, Group Theory in Chemistry, 2nd Edition, Vishal Publications, New Delhi, 2015.
3. K. V. Raman, Group Theory and Its Applications to Chemistry, 2nd Edition, Tata McGraw-Hill, New Delhi, 2015.

Reference Books:

1. D.A. McQuarrie, Quantum Chemistry, 2nd Edition, University Science Books, Mill Valley, California, 2008.
2. T.N. Levine, Quantum Chemistry, 6th Edition, Pearson Education, 2013.
3. I.N. Levine, Quantum Chemistry, 7th Edition, Pearson Education, 2014

Web Sources:

1. https://chem.libretexts.org/Courses/Mount_Royal_University/Chem_1201/UNIT_1%3A_Quantum_Chemistry
2. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/13.applications_of_molecular_symmetry_and_group_theory/03.definition_of_group_and_its_characteristics/et/4842_et_et.pdf

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	Learn the postulates of Quantum mechanics	**K2**
CO2:	Understand the basic principles of quantum mechanics	**K2**
CO3:	Discuss the Heisenberg uncertainty principle	**K4**
CO4:	Apply the approximation methods in quantum chemistry	**K3**
CO5:	Illustrate an electron transfer reactions.	**K2**
CO6	Apply and analysis the point groups simple molecule	**K3**
CO7	Explain the symmetry of non-linear molecules.	**K2**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	-	2	3	3
CO2	3	3	3	2	2	2	-	3	3	3
CO3	3	3	3	2	-	-	-	2	2	2
CO4	3	2	3	3	2	2	2	2	2	2
CO5	3	3	3	2	-	-	-	2	2	2
CO6	3	2	3	3	2	2	2	2	2	2
CO7	3	2	3	3	3	-	-	2	2	2
Average	3	2.4	3	2.4	2.25	2	2	2.2	2.4	2.4

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
0	0	6	1	3

24PMSG21 **INORGANIC CHEMISTRY PRACTICAL – PRACTICAL II**

Course Objective:

- To learn the quantitative determination of compound by volumetric titration method.
- To learn the qualitative analysis of a given salt mixture.
- To develop the ability to document and present their experimental work effectively, including writing detailed lab reports.

I. Volumetric Estimations:

1. Estimation of Zinc
2. Estimation of Magnesium
3. Estimation of Calcium
4. Estimation of Nickel

II. Colorimetric analysis:

5. Estimation of iron
6. Estimation of nickel
7. Estimation of manganese
8. Estimation of copper.

III. Qualitative analysis:

9. Analysis of Salt mixture- I (W, Se, Pb, Cu)
10. Analysis of Salt mixture- II (Te, Th, Al, Fe)
11. Analysis of Salt mixture- III (Ti, Zr, Mn,Co)
12. Analysis of Salt mixture- IV (Ce, V, Ni, Zn)

TOTAL: 30hrs

Text Books:

1. Jeyavathana Samuel, Chemistry Practical Book, G.G.Printers, Chennai.2012.
2. Vickie.M.Williamson, M.Larry Peck, Lab manual for General Chemistry, Cengage Learning India Private Limited, New Delhi. 2009.
3. Theodore E. Brown, H. Eugene LeMay, Bruce E. Bursten, Catherine J. Murphy, Patrick Woodward, and Matthew E. Stoltzfus *The Central Science* 15th edition, published in 2022.

Reference Books:

1. V.V. Ramanujam, *Inorganic Semimicro Qualitative Analysis*, 5th Edition, The National Publishing Company, Chennai, 2015
2. Arthur I. Vogel, *Vogel's Textbook of Quantitative Chemical Analysis*, 7th Edition, Pearson Education Ltd., 2012.
3. Geoffrey Pass, *Practical Inorganic Chemistry: Preparations, Reactions, and Instrumental Methods*,

2nd Edition, Springer Science & Business Media, 2018.

Web Sources:

1. https://www.studocu.com/en-za/document/mangosuthu-university-of-technology/inorganic-chemistry-2/inorganic-chemistry-ii-practicals-guide/17752501.
2. Practical Physical/Inorganic Chemistry II | University of Cape Coast (ucc.edu.gh)
3. Practical Inorganic Chemistry | Mir Books (mirtitles.org)

Course outcomes: At the end of this course, learners will be able to:

CO1	Develop proficiency in the volumetric estimation of metal using complexometric titration techniques.	**K6**
CO2	Understand and apply colorimetric techniques to estimate iron content in various samples, interpreting absorbance data to determine concentrations.	**K2**
CO3	Develop expertise in the colorimetric estimation of copper, applying the Beer-Lambert law for precise quantification.	**K6**
CO4	Identify and qualitatively analyze the presence of W, Se, Pb, and Cu in salt mixtures, using systematic inorganic analysis methods.	**K1**
CO5	Accurately identify and qualitatively analyze the components of salt mixtures containing Ti, Zr, Mn, and Co, utilizing advanced analytical techniques.	**K1**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	3	3	3
CO2	3	3	3	3	3	-	2	3	3	3
CO3	3	3	3	2	3	2	2	3	2	2
CO4	3	3	3	3	2	-	-	2	3	3
CO5	3	3	3	2	3	2	-	3	2	2
Average	3	2.8	3	2.6	2.6	-	2	2.8	2.6	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
		✓	✓	
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
✓	✓		✓	✓

24PMSG22 **PHYSICAL CHEMISTRY PRACTICAL – PRACTICAL III**

L	T	P	O	C
0	0	6	1	3

Course Objective

- To understand and analyze the kinetic and thermodynamic. aspects of reactions.
- To learn the significance of potentiometric and conductometric titrations.
- To gain proficiency in logical deduction skills through written problems and laboratory work.

Non-Electrical experiments:

1. Determination of relative strength of the given 2 acids catalyzed by methyl acetate.
2. Determine the temperature coefficient & energy of activation of hydrolysis of methyl acetate.
3. Construction of Phase diagram for a simple binary system.
4. Determination of rate constant & order of reaction between $K_2S_2O_8$& KI
5. Study of the primary salt effect on the Kinetics of ionic reactions & test the Bronsted relationship ($K_2S_2O_8$ + KI)
6. Determination of equilibrium constant of the reaction between I_2 + KI by Partition method.
7. Study of the adsorption of acetic acid by charcoal (Freundlich isotherm).

Electrical Experiments:

I. Potentiometric titrations:

1. Strong acid Vs Strong Base
2. Weak acid Vs Strong Base
3. Mixture of acid Vs Strong Base
4. Halides Vs AgNO3
5. Mixture of halides Vs AgNO3
6. Redox Titration
a. $FeSO_4$ Vs $K_2Cr_2O_7$ b. KI Vs $KMnO_4$
7. Determination of pKa of a weak acid using Henderson equation.

II. Conductometric titrations:

1. Strong acid Vs Strong base.
2. Strong acid & weak acid Vs Strong base (Mixture of acids Vs Strong base)
3. Weak acid Vs Strong base.
4. Determination of cell constant and verification of Debye-Huckel Onsager equation for strong electrolyte.
5. Determination of dissociation constant of weak electrolyte by conductivity method.

TOTAL: 30hrs

Text Books:

1. P. S. Raghavan, B. Viswanathan, Practical Physical Chemistry, 3rd Edition, Viva Books Private Limited, New Delhi, 2018.
2. B.D. Khosla, V.S. Garg, Senior Practical Physical Chemistry, 7th Edition, R. Chand and Co., New Delhi, 2016.
3. Arthur M. Halpern, George C. McBane, Experimental Physical Chemistry, 2nd Edition, Pearson Education, 2020.

Reference Books:

1. T.A. Findlay, T.A. Kitchner, Practical Physical Chemistry, 3rd Edition, Longmans, Green and Co., 2015.
2. J.M. Wilson, K.J. Newcombe, A.R. Denko, R.M.W. Richett, Experiments in Physical Chemistry, 5th Edition, Pergamon Press, 2016.
3. J.B. Yadav, Advanced Practical Physical Chemistry, 3rd Edition, Krishna Prakashan Media, 2018.

Web Sources:

1. https://studylib.net/doc/6998505/laboratory-4-conductometric-titrations
2. https://www.unige.ch/asso-etud/aecb/rapports/3eme/chianalytique/titration_12.pdf
3. https://people.ok.ubc.ca/pphillips/DRAFT%20464%20Manual.pdf

Course outcomes: At the end of this course, learners will be able to:

CO1	Understand the student will be learning the concept of non-electrical experiments	**K2**
CO2	Learn to construct phase diagram	**K2**
CO3	Explain the concept distribution coefficient	**K3**
CO4	Analyses the hydrolyze of ester	**K4**
CO5	Analyze the weak acid& base and strong acid & base by potentiometric titration	**K4**

Mapping of Program outcomes with course outcomes

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**
CO1	3	2	3	2	2	2	-	3	3
CO2	3	3	3	3	3	-	-	3	3
CO3	3	3	3	2	3	-	2	3	2
CO4	3	3	3	3	2	2	-	2	3
CO5	3	3	3	3	3	2	-	3	2
Average	3	2.8	3	2.6	2.6	2	2	2.8	2.6

Assessment Method

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
		✓	✓	
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
✓	✓		✓	✓

SEMESTER - III

24CMSG31 ORGANIC PHOTOCHEMISTRY AND PERICYCLIC REACTION

L	T	P	O	C
4	0	0	2	4

Course Objective

- To study the structure elucidation of organic molecules using NMR, Mass spectroscopy and IR spectroscopy.
- To know about the general aspects of organic photochemistry.
- To learn about Hetero cycles, terpenoids, steroids and cholesterol.

UNIT-I Introduction to photochemistry 12

Basic concepts of organic photochemistry: Photochemical excitation: Experimental techniques; Thermal versus photochemical reactions – singlet and triplet energy states – comparison of energies, lifetimes and reactivates; allowed and forbidden transitions; fluorescence, phosphorescence and internal conversion – intersystem crossing; Introduction to Photochemistry of aromatic compounds.

UNIT-II Organic Photochemistry 12

Photochemical reactions of saturated ketones – Norrish Type I and Norrish Type II reaction; photo reduction of ketone, photoaddition reactions, Paterno Buchi reaction. Photochemistry of simple olefins – cis – trans isomerization, 1,3-dienes, 1,4- dienes, di – pi methane rearrangement, 1,5 – dienes – sigma tropic rearrangement. Photooxidation – Formation of peroxy compounds – oxidative couplings – Barton reaction. Photo rearrangements: Photo – Fries rearrangement and Photo rearrangement of 2,5 – Cyclohexa dienes. Low temperature photochemistry. Zimmerman approach of photochemical rearrangements.

UNIT-III Pericyclic Reactions 12

Pericyclic reactions- classification –orbital symmetry-Woodward Hoffman rules- Analysis of electrocyclic, interconversion of hexatrienesto cyclohexadienes.Cycloaddition and sigma tropic reactions-Sigmatropic rearrangements: (1,3), (1,5) and (3,3) carbon migration. correlations diagram for butadiene-cyclobutene system. Structure of butylene, a fluxional molecule –Cope and Claissen rearrangements.

UNIT-IV Heterocyclic and Terpenoids 12

Nomenclature – reactivity – aromaticity – spectral properties. Imidazole, oxazole, thiazole, flavones, isoflavones, anthocyanins, pyrimidines (cytocine and uracil only) and purines (adenine, guanine only). Structural elucidation of Camphor, Cadinene, Vitamin A, Abietic acid, Gibberelic acid, Zinziberine and Squalene.

UNIT-V Steroids 12

Classification with examples, nomenclature of steroids; Structure, Conversion of cholesterol to progesterone, estrone and testosterone. Elucidation of structure of cholesterol (by chemical degradation).Conformations of stereoids - molecular rearrangements (acid and base catalyzed, photochemical).

TOTAL: 60hrs

Text Books:

1. M. K. Sharma, Organic Photochemistry and Photochemical Reactions, 2nd Edition, Allied Publishers, 2020.
2. R. K. Gupta, *Steroid Chemistry and Applications*, 3rd Edition, CRC Press, 2021.
3. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, 3rd Edition, Wiley Eastern, 2021.

Reference Books:

1. P. B. Joshi, *Steroid Chemistry and Structural Elucidation*, 2nd Edition, Springer, 2021.
2. R. N. Patel, *Introduction to Heterocyclic Chemistry*, 2nd Edition, Wiley India, 2019
3. R. K. Bhattacharya, *Pericyclic Reactions: Mechanisms and Applications*, 3rd Edition, Oxford University Press, 2020.

Web Sources:

1. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/28%3A_Photochemistry/28.03%3A_Organic_Photochemistry
2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/21%3A_Resonance_and_Molecular_Orbital_Methods/21.11%3A_Pericyclic_Reactions
3. https://www.asu.edu/courses/chm332/PericyclicReactions.pdf

Course outcomes: At the end of this course, learners will be able to:

CO1	Develop a thorough understanding of various types of organic reaction mechanisms, including nucleophilic, electrophilic, and radical reactions.	**K6**
CO2	Understand and Identify reagents, conditions, and mechanisms for key transformations, such as oxidation, reduction, substitution, and elimination reactions.	**K2**
CO3	Analyze and predict reaction outcomes based on electron flow, functional groups, and intermediate stability.	**K6**
CO4	Apply Woodward-Hoffmann rules and molecular orbital theory to predict and rationalize pericyclic reaction pathways and stereochemistry.	**K1**
CO5	Predict and explain stereo chemical outcomes in reactions, applying knowledge of chiral centers, configuration, and conformational analysis.	**K1**
CO6	Analysis of nomenclature of heterocyclic compounds and its jndustrial application	**K6**
CO7	Evaluate the Structure and classification of steroids.	**K2**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	-	3	3	3
CO2	3	3	3	3	3	3	2	3	3	3
CO3	3	3	3	2	3	3	2	3	2	2
CO4	3	3	3	3	2	2	-	2	3	3
CO5	3	3	3	2	3	3	-	3	2	2
CO6	3	3	3	3	3	3	-	3	2	2
CO7	3	3	3	3	3	3	-	3	2	2
Average	3	2.8	3	2.6	2.6	2.6	2	2.8	2.6	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
		✓	✓	
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/Presentation**
✓	✓		✓	✓

24CMSG32 **SOLID STATE CHEMISTRY**

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To understand the Fundamental Concepts of Solid-State Chemistry
- To Introduce Fundamental Concepts of Solid-State Materials Preparation
- To Understanding the Fundamental Electrical Properties of Materials

UNIT-I Crystal Structure **12**

Crystalline and amorphous solids; One- and two-dimensional lattices, crystal systems, Bravais lattices, point groups: α-Po, fcc, bcc metals and their packing efficiency, ionic radii ratios; structure types of ionic solids: CsCl, NaCl, ZnS, spinel and olivine. Polyhedral structure description of solid-State compounds. Frenkel and Schotky defects and colour centers.

UNIT-II Powder x-ray diffraction **12**

Indexing the powder XRD patterns, Systematic absences, Structure factor, determination of lattice type, unit cell parameter and density and other simple compounds .Neutron diffraction.

UNIT-III Preparative ethods: **12**

Solid state reaction, chemical precursor method, co-precipitation, sol-gel, metathesis, self-propagating high temperature synthesis, ion-exchange reactions, intercalation/de intercalation reactions; hydrothermal and template synthesis; High pressure synthesis.

UNIT-IV Methods of Single Crystal Growth: **12**

Solution growth; Melt Growth Bridgeman, Czochralski, Kyropoulus,Verneuil;ChemicalVapourTransport; Fused Salt Electrolysis; Hydrothermal method; Flux Growth. Super conductivity: Basics, discovery and high Tc materials. Thermal analysis: TGA, DTA, DSC

UNIT-V Electrical properties and magnetic properties: **12**

Band theory of solids-metals and their properties; semiconductors - extrinsic and intrinsic, Hall effect; thermo electric effects, insulators-dielectric, ferro electric, pyroelectric and piezo electric properties, multi ferroic. Dia, para, ferro, ferri and antiferro magnetic types; soft and hard magnetic materials; select magnetic materials such as spinels, garnets and perovskites, hexa ferrites and lanthanide-transition metal compounds; magneto resistance.

TOTAL: 60hrs

Textbooks:

1. Lesley Smart and Elaine Moore, Solid State Chemistry: An Introduction, 3rd Edition, CRC Press, 2020.
2. Gary L. Miessler, Donald A. Tarr, and Paul J. L. Williams, Introduction to Solid State Chemistry, 2nd Edition, Pearson Education, 2019.
3. R. J. D. Tilley, Solid State Chemistry: A Primer, 2nd Edition, Wiley, 2019.

Reference Books:

1. Harald Ibach and Hans Lüth, Solid State Physics: An Introduction to Principles of Materials Science, 4th Edition, Springer, 2022.
2. M. H. Loretto, Crystal Chemistry of Modern Materials, 2nd Edition, Elsevier, 2018.
3. Rolf E. Hummel, Electronic Properties of Materials, 5th Edition, Springer, 2017.

Web Sources:

1. https://www.khanacademy.org)
2. (https://pubmed.ncbi.nlm.nih.gov | https://scholar.google.com)
3. https://www.ccdc.cam.ac.uk)

Course Outcomes(CO): At the end of this course, learners will be able to:

Course outcome		**K Level**
CO1	Recall the principles of Solid-state chemistry, crystal structure and amorphous solid	**K1**
CO2	Understand the chemical compositions based on unit cell contents and fractional coordinates.	**K3**
CO3	Explain the preparative methods and thermal analysis	**K4**
CO4	Illustrate the principle single crystal growth	**K3**
CO5	Explain the principle of thermal analysis: TGA, DTA and DSC methods.	**K4**
CO6	Identify and apply a suitable strategy for synthesizing inorganic crystalline solids in polycrystalline and single crystal forms.	**K3**
CO7	To Correlate and Predict structure-composition-properties (magnetic, electrical and optical) in inorganic crystalline solids.	**K6**

Mapping of Program outcomes with course outcomes

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**
CO1	3	2	3	2	2	2	-	2	3
CO2	3	3	3	2	2	3	2	2	3
CO3	2	3	3	2	3	3	2	2	2
CO4	3	2	3	3	2	2	-	2	2
CO5	3	2	3	-	3	3	-	1	2
CO6	3	2	3	-	2	3	2	2	2
CO7	3	2	3	-	3	3	2	2	2
Average	2.8	2.4	3	2.25	2.25	2.6	2	1.8	2.4

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exam	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

24CMSG33 **ELECTROCHEMISTRY: FUNDAMENTALS AND ITS APPLICATIONS**

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To learn the electrochemical aspects of reactions
- To analyze the structure of different compounds by using different Techniques.
- To Understand the principles of spectroscopic methods

UNIT-I Electro Chemistry-I **12**

Mean ionic activity and mean ionic activity coefficient – concepts ionic strength. Nernst equation-redox system- electrochemicalcell-Electrolyticconductance-Kohlraush'slawandits applications, ionic equlibria. Debye- Huckel theory of strong electrolytes – Determination of activitycoefficientbyelectricalmethod–Debye-Huckellimitinglawqualitativeandquantitative verification – Limitation of Debye –Huckel theory at appreciable concentration – Huckel equation – Debye- Huckel –Bronsted equation. Electrolytic conduction- Debye-Huckel-Onsager treatment of the conductance of strong electrolyte-Experimental verification and limitations. Evidence for the existence of ionic atmosphere.

UNIT-II Electro Chemistry-II **12**

Electrode –electrolyte interface – adsorption at electrified interface- electrical double layer – Electro capillary phenomenon– Electro capillary curves, surfactants –Lipmann's equation, interpretation and electro-kinetic phenomena. Zeta potential and its applications. Structure of double layers – Helmholtz – Perrin- Guoy-Chapman and Stern model of electrical double layers. Evidences for electrical double layer.

UNIT-III Electro Chemistry-III **12**

Mechanism of electrode reaction –The concept of rate determining step of an electrode reaction. Transfer coefficients and stoichiometric number - Polarization and over potential –the Butler Volmer equation for one step and multi-step electron transfer reaction – Significance of exchange current density and symmetric factor-transfer coefficient and its significance – Mechanism of the hydrogen and oxygen evolution reactions.

UNIT-IV Spectroscopy-I

12

Interaction of Matter with Radiation – Einstein's theory of transition probability – Rotational spectroscopy of a rigid rotor – Non-rigid rotor – Diatomic and polyatomic molecules. Vibrational Spectroscopy – Harmonic oscillator – Anharmonicity – Vibrational spectra of polyatomic molecules – Vibrational frequencies – Group frequencies – Vibrational coupling – Overtones – Fermi resonance. Electron Spectroscopy: Basic principles, valence and core binding energies, shifts in energies due to chemical forces, photoelectron spectra of simple molecules, Auger transitions, measurement techniques, and applications.

UNIT-V Spectroscopy-II **12**

Equation of motion of spin in magnetic fields–Chemical shift–spin-spin coupling–NMR of simple AX and AMX type molecules –calculation ofcouplingconstants-^{13}C, ^{19}F, ^{31}P NMR spectra – applications –a brief discussion of Fourier transform resonance Spectroscopy.

TOTAL: 60hrs

Text Books:

1. S. Glasstone, Principles and Applications to Electrochemistry, 2nd Edition, Chapman and Hall, 2020.
2. D. R. Crow, Introduction to Electrochemistry, 2nd Edition, Affiliated East-West Press, New Delhi, 2018.
3. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 3rd Edition, Wiley, 2021.

Reference Books:

1. P. H. Rieger, Electrochemistry, 2nd Edition, Chapman and Hall, New York, 2021.
2. G. Aruldas, Molecular Structure and Spectroscopy, 3rd Edition, Prentice Hall, 2018.
3. G. M. Barrow, Introduction to Molecular Spectroscopy, 3rd Edition, McGraw-Hill, New York, 2020.

Web Sources

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry
2. https://chem.libretexts.org/Courses/Northeastern_University/10%3A_Spectroscopic_Methods/10.1%3A_Overview_of_Spectroscopy
3. https://www.slideshare.net/LOKESHPANIGRAHI/spectroscopy-134933430

Course outcomes: At the end of this course, learners will be able to:

CO1	To Memorize and retain the basics of various concepts of interactions between the different ions and implement the concepts of solubility products, common ion effects, relate electrode electrolyte equilibrium and concentration cells	**K1**
CO2	To Understands the activity coefficients and theory of Debye Huckel rule, limitations and its applications.	**K2**
CO3	To Execute the theories of electrode-electrolyte interfaces and kinetics of electrochemical reactions and implements the significance of over voltage and corrosion	**K4**
CO4	To know the concepts of polarisation and corrosion.	**K2**
CO5	To Explain the application of electrochemistry.	**K3**
CO6	To Analyse and evaluate the experimental set up and applications of electro analytical techniques	**K5**
CO7	To Analyze the intricacies of electrical double layer and evaluate its implications in real life.	**K4&K5**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	3	3	3
CO2	3	3	3	3	3	-	2	3	3	3
CO3	3	3	3	2	3	2	2	3	2	2
CO4	3	3	3	3	2	-	-	2	3	3
CO5	3	3	3	2	3	2	-	3	2	2
CO6	3	3	3	3	3	-	2	3	3	3
CO7	3	3	3	3	3	2	2	3	3	3
Average	3	2.8	3	2.6	2.6	-	2	2.8	2.6	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**

24PMSG31 **ANALYTICAL CHEMISTRY PRACTICAL - PRACTICAL IV**

L	T	P	O	C
0	0	6	1	3

Course Objective

- To learn the separation technique and the instrumentation in the analysis of metals.
- To understand the volumetric estimations of organic compounds.

Inorganic Experiments

I. QUANTITATIVEANALYSIS

Gravimetric analysis of mixtures of

1. Iron and magnesium
2. Iron and nickel
3. Copper and nickel
4. Copper and Zinc.
5. Copper and Tin.
6. Calcium and Magnesium
7. Silver and Lead

List of spectra to be given for interpretation.

1. ^{31}PNMR Spectra of methyl phosphate
2. ^{31}PNMR Spectra of HPF_2
3. ^{19}F NMR Spectra of ClF_3
4. ESR Spectra of the aqueous $ON(SO_3)_2^{2-}$ion
5. ESR Spectra of the $[Mn(H_2O)_6]^{2+}$ion
6. IRSpectra of the nitro and nitrito penta amine cobalt (III)chloride
7. IR Spectra of carbonyls
8. Mossbauer spectra of $FeSO_4.7H_2O$
9. Moss bauerspectra of $[Fe(CN)_6]^{3-}$
10. 1HNMR Spectra of aromatic compounds

II. ORGANICEXPERIMENTS:

Any Six Preparations from the following involving two stages:

1. Sym-Tribromo benzene fromaniline.
2. Benzanilide from benzophenone.
3. m-Nitrobenzoic acid from methylbenzoate
4. 2,4-Dinitrobenzoic acid from p-nitrotoluene
5. m-nitrobenzoic acid from benzaldehyde
6. Benzil from benzaldehyde

7. Anthaquinone from phthalicanhydride
8. Phthalide from phthalicanhydride
9. 2-phenylindole from phenylhydrazine
10. 2,4-Dinitrophenylhydrazine from p-nitrochlorobenzene.
11. Preparation of Acetanilide and p-Bromo acetanilide
12. Preparation of Benzoic Acid and p-Nitrobenzoic Acid

Any Five Estimations:

1. Estimation of aniline.
2. Estimation of Phenol
3. Estimation of glucose
4. Estimation of amino group
5. Estimation of amide group
6. Saponification of fator an oil
7. Iodine value of an oil
8. Estimation of sulphur in an organic compound
9. Estimationof methyl ketone.

Special Interpretation of organic compounds, UV, IR, PMR and Massspectra of 10 compounds

1. 3,5-Trimethylbenzene
2. Isopropylalcohol
3. Pinacolone
4. Acetone
5. 2-N,N-Dimethylaminoethanol
6. Benzyl bromide
7. Pyridine
8.Phenylacetone
9. Cinnamaldehyde
10.1,3-dibromo-1,1-dichloropropene.

TOTAL: 30hrs

Text Books:

1. Gary D. Christian, Analytical Chemistry, 8th Edition, John Wiley & Sons, Inc., New York, 2020.
2. V. K. Ahluwalia, Sunita Dhingra, Comprehensive Practical Organic Chemistry – Qualitative Analysis, 2nd Edition, University Press Private Limited, India, 2020.

Reference Books:

1. Russell S. Drago, Physical Methods in Inorganic Chemistry, 2nd Edition, West Press Private Limited, New Delhi, 2015.
2. **Kennedy, J. H.** (2018). *Analytical Chemistry: Practice* (4th ed.). Cengage Learning.

Web Sources:

1. *https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/09%3A_Separation_PurificationIdentification_of_Organic_Compounds*

2. *https://www.masterorganicchemistry.com/2016/11/23/quick_analysis_of_ir_spectra/*

Course outcomes : At the end of this course, learners will be able to:

CO1	Develop skills in quantitative and qualitative analysis, enabling accurate determination of chemical compositions in various samples.	**K6**
CO2	Learn to operate and interpret data from key analytical instruments, such as UV-Vis spectrophotometers, HPLC, GC, and atomic absorption spectrometers.	**K2**
CO3	Use statistical tools to analyze data, interpret results, and assess the significance of experimental findings in analytical chemistry.	**K6**
CO4	Demonstrate proficiency in good laboratory practices, including sample handling, record-keeping, and laboratory safety procedures.	**K1**
CO5	Develop skills in interpreting analytical data, preparing reports, and effectively communicating analytical results.	**K1**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	3	3	3
CO2	3	3	3	3	3	-	2	3	3	3
CO3	3	3	3	2	3	2	2	3	2	2
CO4	3	3	3	3	2	-	-	2	3	3
CO5	3	3	3	2	3	2	-	3	2	2
Average	3	2.8	3	2.6	2.6	-	2	2.8	2.6	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
		✓	✓	
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
✓	✓			✓

24IMSG31 **INTERNSHIP**

L	T	P	O	C
0	0	4	1	2

Course Objective:

- To gain practical experience by working in a professional chemistry-related environment.
- To demonstrate an ability to working dependently and utilize principles of chemistry to solve real-world problems.
- To Provide students with exposure to industry standards, practices, and technologies, helping them develop competencies specific to their career goals.

Course Requirements:

- Students wishing to receive credit for internship are required to find, apply for, and be selected for a chemistry or materials related internship position with an organization of their choice.
- They will then need to seek permission by the Department Chair to register for the appropriate internship course.
- The student must complete at least 90 hr of work during the semester for each hour of academiccreditawarded,andtheseworkhoursmustbecompletedduringtheterm(oddor even semester vacation) in which the student is registered for the internship course.
- After the student has completed the internship, the student must submit the final evaluation reportoftheinternshipexperienceand20minutespresentationtodepartmentatconclusion of semester.
- The Department Chair and class instructor will allot the marks for the internship evaluation report.

Course outcomes: At the end of this course, learners will be able to:

CO1	Demonstrate the ability to apply academic concepts and theories to real-world professional tasks and challenges.	**K6**
CO2	Develop and refine practical, technical, and soft skills relevant to the chosen field of study.	**K2**
CO3	Gain exposure to workplace practices, tools, and technologies, fostering a better understanding of industry standards and workflows.	**K6**
CO4	Solve practical problems and contribute to project outcomes using analytical and innovative thinking approaches.	**K1**
CO5	Establish connections with industry professionals, fostering relationships that can support career development and mentorship opportunities.	**K1**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	3	3	3
CO2	3	3	3	3	3	-	2	3	3	3
CO3	3	3	3	2	3	2	2	3	2	2
CO4	3	3	3	3	2	-	-	2	3	3
CO5	3	3	3	2	3	2	-	3	2	2
Average	3	2.8	3	2.6	2.6	-	2	2.8	2.6	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
✓		✓	✓	✓

SEMESTER IV

24CMSG41 ELECTROANALYTICAL AND SEPARATION TECHNIQUES

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To understand the principles and applications of various chromatographic and separation techniques, including adsorption, partition chromatography, GLC, and HPLC.
- To study the fundamental concepts of electrochemical analysis, including polarography, amperometric titrations, and cyclic voltammetry, and their applications to inorganic systems.
- To explore the interaction of matter with radiation, focusing on spectroscopic techniques such as NMR, FTIR, and UV-Vis spectroscopy, and to develop a practical understanding of detectors and instrumentation used in analytical chemistry.

UNIT–I Introduction to Chromatography 12

Adsorption and partition chromatography, definition of terms, techniques and chemical concept of column, paper, TLC and HPTLC, Construction and operation of column, choice of adsorbents and eluents, techniques of elution, methods of detection, analytical and industrial applications.

UNIT–II Analytical Techniques –I 12

Polarography – theory, apparatus, DME, Diffusion, Kinetic and catalytic currents, Current - voltage curves for reversible and irreversible system, qualitative and quantitative applications to inorganic systems.

UNIT–III Analytical Techniques–II 12

Amperometric titrations – theory, apparatus, types of titration curves, successive titrations and indicator electrodes – Applications. Cyclic voltammetry - theory, application to inorganic systems-Coulometry.

UNIT–IV Separation Technique-I 12

Chromatography: Gas-liquid Chromatography, Principles, Retention Volumes, Instrumentation, Carrier Gas, Columns, Stationary Phase, Detectors, Thermal Conductivity, Flame Ionization, Electron Capture, Application of G.L.C. Principle, comparison of GSC and GLC, instrumentation columns pack and tubular, study of detectors-thermal conductivity. Flame ionization, electron capture and mass spectrometry. Factors affecting the separation, applications.

UNIT–V Separation Technique-II 12

High Performance Liquid chromatography: Scope, Column efficiency, Instrumentation, Pumping Systems, Columns, Column packing, Detectors, Applications. Ion exchange and gel – permeation chromatography. Apparatus, pumps, column packing, charecteristics of liquid chromatographic detectors-UV, IR, refractometer and fluorescences detectors, advantages and applications.

TOTAL: 60 hrs

Text Books:

1. **Pavia, D., Lampman, G. M., & Kriz, G. S.** (2018). *Introduction to Spectroscopy* (4th ed.). Cengage Learning, Florida.
2. **Raman, K. V., Gopalan, R., & Raghavan, P. S.** (2019). *Molecular Spectroscopy* (2nd ed.). Vijay Nicole Imprints, Singapore.
3. **R. K. Sharma** (2021). *Handbook of Instrumental Techniques for Analytical Chemistry*. Wiley Eastern

Reference Books:

1. J. W. Akitt, NMR and Chemistry, 4th Edition, Wiley, 2019.
2. Horst Friebolin, Basic One- and Two-dimensional NMR Spectroscopy, 5th Edition, Wiley-VCH, 2017.
3. N. Levine, Molecular Spectroscopy, 2nd Edition, Pearson Education, 2020.

Web Sources:

1. https://oer.avu.org/handle/123456789/38
2. https://oer.avu.org/bitstream/handle/123456789/38/Separation,+Electroanalytical+and+Spectrometric+Techniques.pdf?sequence=4
3. http://web.iyte.edu.tr/~serifeyalcin/lectures/chem306/cn_2.pdf

Course outcomes: At the end of this course, learners will be able to:

CO1:	To learn about the definition of Adsorption and partition chromatography	**K2**
CO2:	To understand the Column, Paper, Thin Layer Chromatography	**K3**
CO3:	To know about the High Performance Thin Layer Chromatography	**K3**
CO4:	To familiarize the Two dimensional Paper Chromato graphy,Reverse phase paper chromatography.	**K3**
CO5:	To learn about the Gas-liquid Chromatography.	**K4**
CO6:	To understand the concept of Thermal Conductivity, Flame Ionization, Electron Capture and Application of G.L.C.	**K3**
CO7:	To learn the concept of HPLC technique and application.	**K3**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	3	3	3
CO2	3	3	3	3	3	-	2	3	3	3
CO3	3	3	3	2	3	2	2	3	2	2
CO4	3	3	3	3	2	-	-	2	3	3
CO5	3	3	3	2	3	2	-	3	2	2
CO6	3	3	3	3	3	-	-	3	3	3
CO7	3	3	3	3	3	-	-	3	3	3
Average	3	2.8	3	2.6	2.6	-	2	2.8	2.6	2.6

Assessment Methods:

CAT1	**CAT2**	**Model Exam**	**End Semester Exams**	**Assignments**
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
	✓		✓	

24RMSG41 **RESEARCH PROJECT**

L	T	P	O	C
0	0	20	0	10

Course Objectives

- To review literature on a specified topic using scientific research methodology.
- To write a scientifically structured project proposal, highlighting its industrial and commercial relevance.
- To synthesize compounds/complexes and characterize them using various analytical instruments, exploring their potential applications.

The project work may be carried in pharmaceutical industries / National laboratories/R&D centers/ Academic institutions/ National and International Universities in the field of Pharma or Analytical chemistry with emphasis on the academics or applied fields. In-house project may be carried out.

- **Total: 20 hrs**

Course outcomes: At the end of this course, learners will be able to:

CO1	To recall and comprehend the concepts of scientific research methodology for literature survey.	**K1, K2**
CO2	To characterize the synthesized compounds/complexes and to interpret the experimental data systematically.	**K3**
CO3	To explain and infer the chemical, biological, medicinal, industrial and commercial applications of the product obtained.	**K4**
CO4	To report and summarize the findings of their project with respect to its social and environmental importance.	**K4, K5**
CO5	To invent and adopt novel methodologies to solve interdisciplinary projects scientifically at national and international levels.	**K6**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	-	3	3	3
CO2	3	3	3	3	3	-	2	3	3	3
CO3	3	3	3	2	3	2	2	3	2	2
CO4	3	3	3	3	2	-	-	2	3	3
CO5	3	3	3	2	3	2	-	3	2	2
Average	3	2.8	3	2.6	2.6	-	2	2.8	2.6	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
Quiz	MCQ	Projects	Seminars	Demonstration/ Presentation
	✓	✓	✓	✓

DISCIPLINE SPECIFIC ELECTIVE

NUCLEAR AND PHOTOCHEMISTRY

L	T	P	O	C
4	0	0	2	4

Course Objective

- To understand the nuclear fission and nuclear fusion reaction and applications of tracer's techniques.
- To study; the features of inorganic photochemistry like solar energy conversion and photo electrochemistry
- To know the importance of nuclear reactions in the modern world.

UNIT-I Nuclear Force and Electron Capture Detectors 12

Nuclear Binding Energies, nuclear radii, spin and moments, nuclear structure, n/p ratios in stable and meta stable nuclei, nuclear forces, structure of the nucleus - Nuclear Models - liquid drop model - shell model – Radioactive decay- detection and determination of activity by cloud chamber, nuclear emulsion, bubble chamber, G.M., Scintillation and Cherenkov counters.

UNIT- II Nuclear reactions 12

Types of nuclear reactions, nuclear cross section, spallation, nuclear fission and fusion. Theory of fission-chain reaction, critical mass; nuclear reactors-fast breeder reactor, fuels used in nuclear reactors-fissile, fertile separation of isotopes, moderators, coolants. Nuclear fusion; nuclear reactors in India. Particle Accelerators: Cyclotron - synchrocyclotron.

UNIT- III Tracer study 12

Preparations - principles underlying tracer technique - application of tracers in the study of reaction mechanism and in analytical chemistry - neutron activation analysis, isotope dilution analysis - radio chemical determination of age of geological specimen. Tracers as applied to industry and agriculture - radioactive tracer in the diagnosis and treatment in the field of medicine.

UNIT - IV Photochemistry 12

Fundamentals of photochemistry – photochemical laws – emission of radiations – types of photophysical pathways – delayed fluorescence – basic instrumentation of steady-state and time resolved fluorometer – fluorescence emission, solvent and environmental effects, red-edge effects, effects of intermolecular photophysical processes on emission – static and dynamic quenching, Stern-Volmer equation – Jablonski diagram.

UNIT Photochemistry of Inorganic complexes 12

Inorganic photochemistry – photoredox and isomerization process – Photo substitution reactions– photosensitization reactions – photochemistry in energy conversion, application of metal complexes in solar energy conversion; organometallic photochemistry –photochemical reactions in metal carbonyls; Photochemical techniques – flash photolysis – lasers in photochemistry.

TOTAL: 60h

***Textbooks*:**

1.B. Harvey, "Introduction to Nuclear Physics and Chemistry," Prentice Hall, Latest Edition.

2. J. Arnikar, "Essentials of Nuclear Chemistry," New Age International Publishers, 4th Edition, 2018.

3.K.K. Rohatgi-Mukherjee, "Fundamentals of Photochemistry," New Age International Publishers, Reprint Edition, 2019.

***Reference Books*:**

1. D.F. Shriver, P.W. Atkins, and C.H. Langford, *Inorganic Chemistry*, 5th Edition, Oxford University Press, 2016.
2. Arnikar, H. J. (2021). ***Essentials of Nuclear Chemistry*** (5th ed.). New Age International.
3. N.J. Turro, V. Ramamurthy, and J.C. Scaiano, *Modern Molecular Photochemistry of Organic Molecules*, University Science Books, 2018.

Weblink/ websources:

1.https://www.nou.ac.in/econtent/Msc%20chemistry%20paper%202/MSc%20Chemistry%20Paper-II%20UNIT-2.pdf

2.https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch103-allied-health-chemistry/ch103-chapter-3-radioactivity/

3.https://www.studocu.com/in/document/mahatma-gandhi-university/msc-chemistry/photochemistry-1-lecture-notes/44815992

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	To learn what is cloud chamber and bubble chamber.	**K2**
CO2:	To know various reactions of nuclear fission and nuclear fusion.	**K3**
CO3:	To familiarize the nuclear reactors in India	**K3**
CO4:	To learn how radioactive tracer is used in diagnosis and treatment in the field of medicine.	**K3**
CO5:	To learn the concepts of solar energy conversion	**K4**
CO6	To understand the fundamental principles of photochemistry, including the interaction of light with matter and the absorption and emission of light by molecules.	**K3**
CO7	To identify the various photo physical processes, such as fluorescence, phosphorescence, and non-radioactive decay.	**K3**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	2	2	3	2
CO2	3	3	3	3	2	-	-	2	3	3
CO3	3	3	3	2	3	-	-	3	2	2
CO4	3	3	2	2	2	2	-	2	2	3
CO5	3	3	3	2	3	2	2	3	2	2
CO6	3	3	2	3	3	2	-	3	2	2
CO7	3	3	2	2	3	-	2	3	2	2
Average	**3**	**3**	**2.6**	**2.4**	**2.6**	**2**	**2**	**2.4**	**2.4**	**2.4**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/Presentation**
			✓	✓

SPECTROSCOPIC METHODS

L	T	P	O	C
4	0	0	2	4

Courses objective

- To learn the theory and application of various spectroscopic techniques, such as IR, NMR, UV-Vis and MS
- To understand the strengths and limitations of each spectroscopic techniques and choose appropriate methods for specific analytical problems.
- To communicate effectively about spectroscopic results, including written and oral presentation

UNIT-I Techniques of UV-Visible spectroscopy and Infrared Spectroscopy 12

Colorimetric analysis and UV-Visible spectroscopy: Beer Lambert's law, Principles of single and double beam instruments–applications for analysis of inorganic and organic samples. Infrared spectro photometric analysis–principle and instrumentation and molecular structure determination.

UNIT–II Raman Spectra 12

Raman Spectra–principle, basic instrumentation–structural analysis.

UNIT–III Nuclear Magnetic Resonance 12

Nuclear Magnetic Resonance–Principle, instrumentation structure determination, NMR of ^{1}H, ^{13}C, ^{31}P, ^{19}F.

UNIT–III Electron Spin Resonance 12

Electron Spin Resonance–Principle, instrumentation, applications to coordination compounds.

UNIT-V Mass Spectrometry 12

Mass Spectrometry–Principle, basic instrumentation, fragmentation patterns –organic molecular structural determination.

TOTAL: 60

Text books:

1. Silverstein, R. M., Webster, F. X., & Kiemle, D. J. (2021). *Spectrometric Identification of Organic Compounds* (9th ed.). Wiley.
2. B.K. Sharma, *Instrumental Methods of Chemical Analysis*, 6th Edition, Goel Publishing House, 2019.
3. Gurdeep R. Chatwal and Sham K. Anand, *Instrumental Methods of Chemical Analysis*, 3rd Edition, Himalaya Publishing House, 2019.

Reference books:

1. Sharma, B. K. (2021). Instrumental Methods of Chemical Analysis (5th ed.). Goel Publishing House.
2. Williams, D. H., & Fleming, I. (2022). Spectroscopic Methods in Organic Chemistry (8th ed.). McGraw-Hill Education.
3. Dyer, J. R. (2021). Applications of Absorption Spectroscopy of Organic Compounds (4th ed.). Prentice-Hall India Pvt. Ltd.

Websites/ Web sources:

1. https://www.slideshare.net/Santachem/uv-visible-spectroscopy
2. https://www.slideshare.net/Preetichaudhary55/electron-spin-resonance-spectroscopy-145343647
3. https://www.slideshare.net/msakhan61/atomic-absorption-spectroscopy-aas-129450445

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	Analyze the spectroscopic data to identify and characterize molecules	**K4**
CO2:	Apply spectroscopic methods to quantitative analysis	**K3**
CO3:	Choose appropriate spectroscopic techniques for specific analytical problems	**K3**
CO4:	Interpret spectroscopic results in the context of chemical structure and bonding	**K2**
CO5:	To understand the ESR spectra, properties of materials, including defects, impurities and surface properties .	**K2**
CO6	Analyze NMR spectra to determine the structure and properties of molecules	**K4**
CO7	Analyze mass spectra to determine the structure and properties of molecules	**K4**

Mapping of Program outcomes with course outcomes

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	3	-	2	2	3	2
CO2	3	3	3	3	2	-	-	2	3	3
CO3	3	3	3	2	3	-	-	3	2	2
CO4	3	3	2	2	2	2	-	2	2	3
CO5	3	3	3	2	3	2	2	3	2	2
CO6	3	3	2	3	3	2	-	3	2	2
CO7	3	3	2	2	3	-	2	3	2	2
Average	**3**	**3**	**2.6**	**2.4**	**2.6**	**2**	**2**	**2.4**	**2.4**	**2.4**

Assessment Methods

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/P resentation**
			✓	✓

CHEMISTRY OF NATURAL PRODUCTS

L	T	P	O	C
4	0	0	2	4

Courses objective

- To study the diversity and complexity of natural products, including their classification, structure and biosynthesis
- To learn about the isolation, purification and characterization of natural products
- To study chemical reactions and mechanism involved in the biosynthesis of natural products

UNIT–I Alkaloids **12**

Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen hetero cyclicring, role of alkaloids in plants. Structure, stereochemistry, synthesis of the following: Ephedrine, Atropine, Quinine and Morphine

UNIT–II Steroids-I **12**

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon, stereochemistry, isolation, structure determination and interconversions of steroids.

UNIT–II Steroids-II **12**

Bile acids, Androsterone, Testosterone, Estrone, Progestrone, Aldosterone and bio synthesis of cholesterol

UNIT–IV Terpenoids **12**

Terpenoids- Classification, Isoprenerule, Structural elucidation of chemical degradation and synthesis of camphor, Squalene, and Abetic acid.

UNIT–V Carbohydrates Prophyrins and Rotenoids **12**

Carbohydrates –Oligosaccharides, trisaccharides glycosides. Structural Elucidation of Starch and cellulose, Primary concept. Porphyrin: Structure and synthesis of Haem and Chlorophyll. Rotenoids: Structure determination and synthesis of rotenone.

TOTAL : 60hrs

Text books:

1. **R.O.C. Norman**, *Principles of Organic Synthesis*, 4th Edition, Chapman and Hall, London, 2016.
2. **E.S. Gould**, *Structure and Mechanism in Organic Chemistry*, 2nd Edition, Henry Holt and Co., New York, 2018.
3. Mookerjee, J. D., & Singh, S. P. (2020). *Organic Chemistry - Volume 2 (Indian Edition)*. S. Chand Publishing.

Reference books:

1. B. S. Bahl & Arun Bahl**, *Advanced Organic Chemistry: Reaction Mechanisms*, 10th Edition, S. Chand & Co., 2022.**
2. T. W. Graham Solomons & Craig B. Fryhle**, *Organic Chemistry*, 12th Edition, Wiley, 2021.**
3. Satyanarayana, U., & Chakrapani, U. (2019). Biochemistry. Books & Allied (P) Ltd.

Websites/websources:

1. https://www.intechopen.com/books/alkaloids-their-importance-in-nature-and-human-life/introductory-chapter-alkaloids-their-importance-in-nature-and-for-human-life

2. https://www.slideshare.net/slideshow/alkaloids-terpenoids-glycosides/273701878

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	To learn the general aspects of alkaloids in plants.	**K2**
CO2:	To know the structure, stereochemistry and synthesis of quinine and morphine.	**K3**
CO3:	To learn about the occurrence, nomenclature and basic skeleton of steroids.	**K3**
CO4:	To elucidate the structure and interconversion of steroids.	**K3**
CO5:	To understand the types of steroids.	**K4**
CO6	To learn about the terpenoids compound synthesis and applications	**K3**
CO7	To know the carbohydrate structure and synthesis and properties	**K3**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	-	-	2	3	2
CO2	3	3	3	3	3	-	-	2	3	3
CO3	3	3	3	2	3	-	2	3	2	2
CO4	3	3	3	3	2	2	-	2	2	3
CO5	3	3	2	2	3	2	2	3	2	2
CO6	3	3	2	2	3	2	-	3	2	2
CO7	3	3	2	2	3	-	2	3	2	2
Average	**3**	**3**	**2.6**	**2.4**	**2.6**	**2**	**2**	**2.4**	**2.4**	**2.4**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/Presentation**
			✓	✓

MACROMOLECULAR CHEMISTRY

L	T	P	O	C
4	0	0	2	4

Courses objective:

- To understand the structure, properties and synthesis of macromolecules
- To Analyze the chemical reactions and mechanism involved in the formation and degradation of macromolecules
- To understand the characterization techniques used to analyses macromolecules

UNIT–I Basic Concepts of Polymers. 12

Monomer, Repeating unit, degree of polymerization. Classification of polymers, Stereochemistry of polymer, nomenclature of stereo regular polymers.. Plastics – Types of plastics - Rubber – Natural and synthetic rubber - Vulcanisation of rubber**..**

UNIT-II Types of Polymerizations 12

Types of polymerization - Chain polymerization, free radical polymerization; ionic polymerization; Coordination polymerization and Ziegler Natta catalyst, Step polymerization, ring opening polymerization. Co polymerization, random, block and graft co polymers- preparation. Polymerisation techniques; bulk, solution, suspension and emulsion polymerization.

UNIT-III Molecular Weight and Glass Transition Temperature 12

Measurement of molecular weight and size; number average and weight average molecular weights. Glass transition temperature, concepts of glass transition temperature and associated properties. Molecular weight determination by light scattering, osmotic, centrifuge and viscosity methods. Gel permeation chromatography. Analysis and testing of polymer by FT-IR, NMR, XRD, TGA/DTA/DSC.

UNIT-IV Glassy Solids and Polymer Crystallization 12

Glassy solids and glass transition, factors influencing glass transition temperature (Tg). Crystallinity in polymers; Polymer crystallization, structural and other factors affecting crystallisability, effect of crystallinity on the properties of polymers.

UNIT–V Types of Polymers and Polymer Degradation 12

Polymer degradation: Types of degradation- thermal, mechanical, photo, hydrolytic and oxidative degradations. Additives for polymers: Fillers, plasticizers, thermal stabilizers, photo stabilizers, antioxidants and colourants. Polymers in catalysis and drug delivery, Thermosensitive and photo-sensitive polymers, thermally stable polymers, Biodegradable polymers, Conducting polymers, Fire retardant polymers, polymer electrolytes, Liquid crystalline polymers, Dentrimers, Adhesives, Foams, Fibers.

TOTAL: 60 hrs

Text book

1.**Fred W. Billmeyer,** *Textbook of Polymer Science*, John Wiley & Sons, 4th Edition, 2019.

2. **R. V. Gowariker,** *Polymer Science*, New Age International Publication, 3rd Edition, 2019.

Reference Books:

1. **R. J. Young and P. A. Powell,** *Introduction to Polymers*, CRC Press, 4th Edition, 2017.
2. **A. Ravve,** *Principles of Polymer Chemistry*, Springer, 4th Edition, 2022.

Websites/Websources:

1. *https://nptel.ac.in/courses/103/106/105106205/*
2. *https://nptel.ac.in/courses/104/105/104105039/*
3. *.https://www.slideshare.net/guest824336/ppp8-glassy-state-and-glass-transition-temperature*

https://www.slideshare.net/ssuser3546ce/types-of-polymer-degradation

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	To know about basic ideas of polymers like monomer, repeat unit and degree of polymerization.	**K2**
CO2:	To learn about the stereochemistry and nomenclature of polymers.	**K3**
CO3:	To understand the various types of polymerizations.	**K3**
CO4:	To know the preparation and polymerization techniques.	**K3**
CO5:	To understand the number average and weight average molecular weights.	**K4**
CO6	To learn about the concepts of glass transition temperature.	**K3**
CO7	To know the various factors influencing glass transition temperature.	**K3**

Mapping of Program outcomes with course outcomes

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	3	-	3	2	2	-	2	2	3	2
CO2	3	3	3	-	2	-	2	-	3	3
CO3	-	3	3	2	-	-	-	2	2	2
CO4	3	-	3	3	2	2	2	2	2	3
CO5	3	2	2	-	3	2	3	1	2	2
CO6	3	2	3	3	3	2	3	2	3	2
CO7	3	2	3	3	3	2	3	2	3	2
Average	3	2.66	2.8	2.33	2.25	2	2.25	2.25	2.4	**2.4**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

NUMERIC METHODS FOR COMPUTATIONAL CHEMISTRY

L	T	P	O	C
4	0	0	2	4

Course Objective:

- The main objective of the course is to introduce Linux operating system and basic commands used in terminal, to provide basic knowledge of Fortran/C coding, to explain the numerical methods commonly used in computation chemistry.
- The course objectives also lies in the knowledge of electronic structure calculations of molecular systems in terms of methods, basis set and different calculations.
- Finally, the course targets to provide knowledge on computational chemistry research areas.

Unit - I Introduction to Programming Language in Scientific Computing **12**

Elements of computational programming, basic program structure, data types, logical and arithmetic expressions, loops and control statements, arrays, input/output statements, format specifications, file processing, functions, subroutines and applications.

Unit - II Numerical Methods **12**

Errors, accuracy and stability. Curve fitting: least square fit algorithm. Roots of equations: Newton-Raphson method, Bisection method. Numerical integration: Trapezoidal and Simpson's rules. Numerical differentiation: forward, backward and centred differencing. Interpolation: Lagrange's method. Linear simultaneous equations: Gaussian elimination and Gauss-Jordan elimination.

Unit – III Review of electronic structure theory **12**

Hatree-Fock, MP2, DFT, configuration interaction, basis sets, convergence

Unit-IV Applications **12**

Geometry optimization, frequency calculation, location of transition state, intrinsic reaction co-ordinates, molecular orbitals and population analysis, natural bond orbital analysis, calculation of equilibrium constants and rate constants.

Unit V: Suggested Practical **12**

Development of computer program to solve differential equations arise in Lotka-Volterra Autocatalytic Reaction**.** Geometry optimization of biologically relevant molecules by using any quantum chemistry package, namely, GAUSSIAN, GAMMES, NW Chem, etc.Molecular dynamics on a dissociation reaction to validate Arrhenius theory of reaction rate**.** Quantum Dynamics on a simple system to show the procedure to obtain photo absorption spectra.

TOTAL: 60 hrs

Text Book:

1. Young, D. (2021). *Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems* (2nd Ed.). Wiley.
2. Jensen, F. (2021). *Introduction to Computational Chemistry* (4th Ed.). Wiley.
3. Choudhury, B. R. K. (2021). *Computational Chemistry: A Guide for Chemists and Biologists*. New Age International.

Reference Book:

1. M. Schatzman, "Numerical Analysis: A Mathematical Introduction", Oxford University Press.
2. C. J. Cramer, "Essentials of Computational Chemistry - Theories and Models", John Wiley and Sons Ltd.
3. D. Young, Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems, John Wiley and Sons Ltd.

Weblink/ WebSources:

1. https://nptel.ac.in/courses/104101002
2. NPTEL: Chemistry and Biochemistry - NOC: Computational Chemistry and Classical Molecular Dynamics
3. https://archive.nptel.ac.in/course.html

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	Learn to operate Linux operating system	**K2**
CO2:	Write basic codes in Fortran/C language	**K3**
CO3:	Learn the numerical methods to apply in order to deal with the solution of different equations in Chemistry	**K3**
CO4:	Do electronic structure calculations in terms of geometry and transition state optimization, single point energy calculation, and the calculation of potential energy surface of molecular systems	**K3**
CO5:	Apply specific numerical techniques to solve critical Chemistry problems in quantum mechanics, chemical kinetics, molecular dynamics, etc.	**K4**
CO6	Grab an idea of current research interests in theoretical chemistry field	**K3**
CO7	To know the development of computer program to solve differential equations	**K3**

Mapping of Program outcomes with course outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	-	3	2	2	-	2	2	3	2
CO2	3	3	3	-	2	2	-	-	3	2
CO3	-	3	3	2	-	2	2	2	2	3
CO4	3	-	3	3	2	3	2	2	2	3
CO5	3	2	3	-	3	-	3	1	2	2
CO6	3	2	3	-	-	-	3	-	3	2
CO7	3	2	3	2	2	2	-	2	3	2
Average	3	2.66	3	2.33	2.25	2.33	2.25	-	2.4	**2.4**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/Presentation**
			✓	✓

BIO-INORGANIC CHEMISTRY

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To provide an understanding of the fundamental concepts in bioinorganic chemistry, including the roles of metals in biological systems.
- To explore the structure and function of metallo enzymes, oxygen carriers, and the process of nitrogen fixation.
- To investigate the mechanisms behind photosynthesis, biological redox systems, and the toxicity of heavy metals in biological systems.

UNIT – I Basic concepts of Bioinorganic Chemistry **12**

Thermodynamics and biology – Basic concepts of structure and functionality of membranes – structure, function transport properties, aspects of electrochemical phenomena – active transport, ionophores, biological energy storage and Phosphate hydrolysis.

UNIT – II Metallo Enzymes **12**

Structural and Functionsl relstionships and mechanism of enzymatic reactions of the following metalloenzymes: Zinc Enzymes: carbonic anhydraseand carboxypeptidase, Copper Enzymes: Super oxide dimutases. Iron Enzyme: Catalase and peroxidases, Molybdenum Enzymes:Nirogenase and Xanthanine oxidase

UNIT – III Hemeproteins and Metal Nucleic acid interactions **12**

Oxygen carriers – Hemeproteins – Hemoglobin, myoglobin – Structure Oxygenation and Stereochemistry – Bohr effect. Non-heme oxygen carriers – Hemerythrin and hemocyanin-Iron storage and transport proteins. Nucleic acid introduction, Structure and binding sites in nitrogen base, phosphate and sugar base.

UNIT – IV Nitrogen fixation and biological redox systems **12**

Nitrogen fixation – Introduction, types of nitrogen fixing micro-organisms. Nitrogenase enzyme – Metal clusters in nitrogenase – redox property – Dinitrogen complexes – transition metal complexes of dinitrogen – nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia. Biological redox systems: Cytochromes – Classification, cytochrome a, b and c Cytochrome P-450.

UNIT – V Bio analytical Chemistry **12**

Bio analytical Chemistry, Toxicity & medicine, Toxicity of Hg, Cd, Zn, Pb, As, Sb. Anti cancer agents, Metal ion poisoning: Failure of metal ion control systems, role of metal ion Diagnosis and treatment – use of radio isotopes; Pollution studies: Effluents and treatment. Inorganic plant nutrition and indicator plants for mineral exploration**.**

TOTAL: 60hrs

Text books:

1. D. R. Williams, Introduction to Bioinorganic Chemistry, C.C. Thomas, Springfield, 2nd Edition, 2018.
2. M. Satake and Y. Mido, Bioinorganic Chemistry, Discovery Publishing House, New Delhi, 2nd Edition, 2018.

Reference Books:

1. S. J. Lippard and J. M. Berg, "Principles of Bioinorganic Chemistry," University Science Books, 2021
2. **J. Huheey,** *Inorganic Chemistry*, Harper and Collins, New York, 5th Edition, 2017.

Websources / Websites:

1. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Book%3A_Inorganic_Chemistry(Saito)/08%3A_Reaction_and_Physical_Properties/8.02%3A_Bioinorganic_chemistry
   https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%202.pdf
2. https://authors.library.caltech.edu/25052/1/BioinCh.pdf
3. https://www.slideshare.net/SaiPraveenReddy/bioanalytical-ppt

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	Understand the basic concepts of bioinorganic chemistry.	**K2**
CO2:	Learn about the essential metal ions and their roles in biological systems.	**K3**
CO3:	Explore heme proteins and porphyrin complexes	**K3**
CO4:	Comprehend biological redox systems, metal clusters, and nitrogen fixation	**K4**
CO5:	Gain knowledge of bioanalytical chemistry	**K4**
CO6	Understand the principle of stability constants through spectrophotometric methods.	**K3**
CO7	Learn about the theories of coordination chemistry	**K3**

Mapping of Program outcomes with course outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	3	3	2	2	2	2	2
CO2	2	3	2	3	3	3	2	2	2	2
CO3	3	3	2	3	3	3	2	3	2	2
CO4	2	2	3	3	2	2	3	2	3	3
CO5	3	2	3	3	3	2	2	3	3	3
CO6	3	3	2	3	3	3	2	3	2	2
CO7	2	2	3	3	2	2	3	2	3	3
Average	2.6	2.6	2.43	3	2.7	2.43	2.3	2.43	2.43	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

STRATEGIC MANAGEMENT OF PHARMA INDUSTRY

L	T	P	O	C
4	0	0	2	4

Course Objective:

- To know about pharma industry, technology opportunity for innovation, project evaluation, intellectual property protective and business strategy.
- To provide students with a comprehensive understanding of the pharmaceutical industry's structure, trends, challenges, and opportunities.
- To analyze Examine various competitive strategies employed by pharmaceutical companies to maintain or gain market share

UNIT- I Introduction and Technology Evolution 12

Pharma industry-Specifics, Importance and role in health sector; the Global scenario and Positioning of Indian Pharma industry ; Specific challenges of the Pharma industry versus the general industrial matrix; Understanding technological change; Need for technology strategy as step towards innovation and competitive advantage.

UNIT - II Opportunity for Innovation 12

Technological, Political and Regulatory changes, Diversification, Demographic changes; Research and Development (R&D); Investment in R&D and return on investment – a profit centre; Linking of Research and Development for leverage; Cost reduction exercises.

UNIT-III Project evaluation 12

Managing uncertainty, Analytical hierarchy process, Net Present Value(NPV), Internal Rate of Return(IRR), scenario analysis and decision tree; Portfolio Management, customer- friendly solutions; Product pricing ; Market segmentation and market research.

UNIT-IV Intellectual Property Protection 12

Role of IP protection in knowledge era; Patents- process and Product and the patenting process; Lead molecule development and cost; ANDA; Patent litigation; Non- disclosure agreement; Expiry of patents and generic drugs marketing and issues in IP.

UNIT-V Business strategy 12

Networking; Joint venturing; Licensing; Contract manufacturing; Outsourcing; Human resource management of technical professionals- R&D personnel, Product Development team, Cross-Functional team, Internal communication, Organization structure- decentralizing R&D, acquisitions.

TOTAL: 60 hrs

Text Books:

1. Technology Strategy for Managers and Entrepreneurs" by Scott Shane, Pearson Education, 2021.
2. Small Business Management: Entrepreneurship and Beyond" by Justin G. Longenecker, Carlos W. Moore, and J. William Petty, Cengage Learning, 2021

Reference Book:

1. C.B. Gupta and S.S. Khanka, Entrepreneurship and Small Business Management, Sultan Chand & Sons, New Delhi, 2022.
2. Allen Amason and Andrew Ward, Strategic Management: From Theory to Practice" published by Routledge, an imprint of Taylor & Francis Group, 2020.

Websites/Websources:

1. https://nptel.ac.in/courses/110/108/110108047/
2. https://nptel.ac.in/courses/110/105/110105035/
3. https://www.wipo.int/edocs/mdocs/tk/en/wipo_iptk_ge_14/wipo_iptk_ge_14_wipo_presentation_1.pdf

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1:	To know the various pharma industry and their role in health sector.	**K2**
CO2:	To understand technological change, innovation and benefits.	**K3**
CO3:	To learn the evolution in technology.	**K3**
CO4:	To understand how to invest in R and D and its return on investment.	
CO5:	To familiarize the evaluation of project.	**K4**
CO6	To know the principle and concepts of intellectual properties and production	**K3**
CO7	To know about business strategy and networking	**K3**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	2	2	2	2
CO2	2	3	2	3	3	3	2	2	2	2
CO3	3	3	2	3	3	3	2	3	2	2
CO4	2	2	3	3	2	2	3	2	3	3
CO5	3	2	3	3	3	2	2	3	3	3
CO6	2	3	2	3	2	3	3	3	2	2
CO7	3	2	3	3	3	2	2	2	3	3
Average	2.6	2.6	2.43	3	2.7	2.43	2.3	2.43	2.43	2.6

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
4	0	0	2	4

MEDICINAL CHEMISTRY

Course Objective

- To learn about body absorbs, distributes, metabolizes, and excretes drugs (pharmacokinetics) and understanding the biochemical and physiological effects of drugs on the body.
- To learn about the use of SAR studies to iteratively modify compounds, aiming to enhance desired effects and minimize adverse effects.
- To learn about the creating chemical compounds that interact with the identified drug targets in a way that modulates their activity

Unit- I Introduction to Medicinal Chemistry 12

History and development of medicinal chemistry, Physicochemical properties in relation to biological action such as Ionization, Drug distribution and pKa values of specified APIs such as hydrogen bonding, protein binding, chelation, isosterism, stereoisomerism, steric effect, redox potential and surface activity.

Unit -II Drug metabolism 12

General pathways of drug metabolism (different types of reaction in phase-I and phase-II with example).The role of liver in drug metabolism. Factors affecting drug metabolism including stereo chemical aspects.

Unit- III Drug design 12

Drug discovery and development - lead compounds - factors governing drug design types of drugs – literature survey for preparation of drugs – spectral characterization of drugs Molecular docking: Rigid docking, flexible docking, manual docking, De Novo drug design techniques: Receptor/enzyme cavity size prediction.

Unit -IV Basic concepts of prodrugs 12

Basic concepts of prodrugs need for prodrugs, specific prodrugs such as methodology of prodrug design. Applications of prodrugs.

Unit -V Drugs acting on Central Nervous System 12

Inhalation anesthetics**,** Ultra short acting barbitutrates, Dissociative anesthetics **:** Narcotic and non-narcotic analgesics Morphine and related drugs: SAR of Morphine analogues, Morphine sulphate, Codeine. Anti-inflammatory agents: Sodium salicylate, Aspirin, Mefenamic acid.

Total: 60 hrs

Text Book

1. Ashutosh Kar, *Medicinal Chemistry*, 4th Edition, New Age International Ltd., 2020.
2. M.O. Faruk Khan, Ashok Philip, Fundamentals of Medicinal Chemistry and Drug Metabolism, 2018.
3. Chandrajit Dohutia**,** Kabita Gogai**,** Satyendra Deka**,** *A Textbook of Medicinal Chemistry*, Vol. I, 1st Edition, 2019

Reference Books

1. **William O. Foye**, *Principles of Medicinal Chemistry*, 8th Edition, Wolters Kluwer, 2017.
2. **Graham L. Patrick**, *An Introduction to Medicinal Chemistry*, 5th Edition, Oxford University Press, 2017.

Websource / Weblink

1. https://www.meripustak.com/Medicinal-Chemistry-2Nd-Editiohttps://www.meripustak.com&gclid=Cj0KCQjw8IaGBhCHARIsAGIRRYqqVdgofV

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1	To understand the chemical compounds that exhibit high potency against the target and selectivity for the intended biological pathways, minimizing off-target effects	**K3**
CO2	To know the Improvement of drug-like properties, including absorption, distribution, metabolism, and excretion (ADME).	**K2**
CO3	To ensure optimal bioavailability and effective delivery of the drug to the target site.	**K4**
CO4	To understanding of the relationship between the chemical structure of a drug candidate and its pharmacological activity.	**K2**
CO5	To analysis the facilitating the design and synthesis of more efficacious and safe compounds.	**K3**
CO6	To progression of lead compounds through preclinical studies and into clinical trials, with a focus on demonstrating safety, efficacy, and therapeutic benefit in human subject	**K4**
CO7	To gain the knowledge of **b**asic concepts of prodrugs	**K3**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	3	2	2	2
CO2	2	3	2	3	3	3	3	2	2	2
CO3	3	2	3	3	3	2	3	2	3	2
CO4	2	2	3	3	3	3	3	2	2	3
CO5	3	2	3	3	2	3	3	2	3	3
CO6	2	2	2	3	2	2	3	3	3	3
CO7	3	3	3	3	3	3	3	3	3	2
Average	**2.6**	**2.43**	**2.6**	**3**	**2.7**	**2.57**	**3**	**2.3**	**2.6**	**2.57**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
4	0	0	2	4

EXPERIMENTAL METHODS IN CHEMISTRY

Courses objective:

- To develop laboratory skills and techniques
- To understand the scientific method and experimental design
- To apply the chemical concepts to real-world problems
- To cultivate data analysis and interpretation skills

Unit-I Vacuum and Gas Pressure: **12**

Concepts of vacuum (Low, medium, high and ultra-high vacuum; vacuum pumps and gauges; pressure measurements;); kinetic theory concepts (molecular density; mean free path of particles in the gas phase; incident molecular flux on surfaces; gas exposure; sticking coefficient; surface coverage; variation of parameters with pressure).

Unit-II Imaging and Depth Profiling **12**

Basic concepts in surface imaging; secondary electron microscopy (SEM); secondary Auger microscopy (SAM); scanning probe microscopy (SPM); scanning tunneling microscopy (STM); transmission electron microscopy (TEM); surface imaging; depth profiling. Associated techniques of microscopy and spectroscopy.

Unit-III Chemical Analysis **12**

Non-destructive techniques: Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy (TDS). Destructive techniques.

Unit-IV Atomic absorption spectroscopy (AAS) and Electroanalytical Techniques **12**

Inductively coupled plasma-atomic emission spectroscopy (ICP-AES).: Voltametry;coulometry; amperometry; potentiometry; polarography; electrolytic conductivity; impedance spectroscopy.

Unit-V Separation Methods **12**

Normal and reversed phase liquid chromatography (NP- & RPLC); Gas Chromatography (GC); GC-MS; High Performance Liquid Chromatography (HPLC); Size-Exclusion Chromatography (SEC);Ion Chromatography (IC).

Total: 60 hrs

Text Books:

1. **Mark F. Vitha**, *Chromatography: Principles and Instrumentation*, Wiley, 2019.

2. **Allen J. Bard and Larry R. Faulkner**, *Electrochemical Methods: Fundamentals and Applications*, 3rd Edition, Wiley, 2020.

3. **R. Gopalan and K. S. Viswanathan**, *Analytical Methods*, Orient Blackswan, 2018.

Reference books:

1. John F. O'Hanlon, *A User's Guide to Vacuum Technology*, 4th Ed., Wiley, 2019.

2. Peter W. Hawkes and John C.H. Spence (Eds.), *Springer Handbook of Microscopy*, Springer, 2019.

3. **T. Pradeep**, *Nano: The Essentials*, McGraw-Hill Education, New Delhi, 2010.

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1. https://www.asianhhm.com/articles/medical-gases-and-vacuum-systems-in-hospitals
2. https://blog.ashcroft.com/absolute-vacuum-and-compound-pressure
3. https://milnepublishing.geneseo.edu/introtovacuumtech/chapter/an-introduction-to-vacuum-systems/

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1	Identify and explain the different types of pressure measurement instruments	**K3**
CO2	To utilize imaging and depth profiling techniques to visualize and analyze the composition and structure of materials at the micro-and nano-scale and interpret the resulting data to draw meaningful conclusions.	**K2**
CO3	Apply appropriate analytical techniques to determine the chemical composition and structure of stu and accurately interpret.	**K4**
CO4	Analyze and quantify the concentration of elements in a sample using atomic absorption spectroscopy and interpret the results to draw meaningful conclusion	**K2**
CO5	Apply electro analytical techniques to investigate electrochemical systems, including data collection, analysis and interpretation	**K3**
CO6	To understand a supplement in one or more of the source mixture's constituents	**K4**
CO7	Design and propose experiment to investigate pressure-related phenomena	**K3**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	3	2	2	2
CO2	2	3	2	3	3	3	3	2	2	2
CO3	3	2	3	3	3	2	3	2	3	2
CO4	2	2	3	3	3	3	3	2	2	3
CO5	3	2	3	3	2	3	3	2	3	3
CO6	2	2	2	3	2	2	3	3	3	3
CO7	3	3	3	3	3	3	3	3	3	2
Average	**2.6**	**2.43**	**2.6**	**3**	**2.7**	**2.57**	**3**	**2.3**	**2.6**	**2.57**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
4	0	0	2	4

FUNCTIONAL ORGANIC MATERIALS

Course objectives:

- To study the relationships between molecular structure, properties and function in organic materials
- To understand the design, synthesis and properties of functional organic materials
- To communicate effectively about the design, synthesis and applications of functional organic materials.
- To understand the challenges and opportunities in the development of functional organic materials for various applications

Unit-I Organic Electronic Materials: **12**

Basic theory and design of Molecular wires, Resistors, Diodes, Transistors/OFETs, and OLEDs - Introduction to various device configurations and working principles

Unit-II Organic Photonic Materials: **12**

Basic theory and design of molecules for Organic solar cells – Various approaches and introduction to some device aspects – Molecules for NLO and imaging – Molecular switches, Motors and Memories – Chirooptical materials and Photorefractive materials

Unit-III Organic Energy Materials: **12**

Basic theory and design of Organic Flow Batteries for Energy Storage applications – High energy materials – Covalent Organic Frameworks

Unit-IV Organic Molecular Machines: **12**

Types – Design, synthesis, and function – Examples

Unit-V Miscellaneous Materials: **12**

Basic theory and design of materials for Organogels, Organic Sensors and Logic Gates, Organic Magnets, Organic Superconductors, Organic Thermo electrics.

Total: 60 hrs

Text Books:

1. **T. J. J. Müller and U. H. F. Bunz**, *Functional Organic Materials*, Wiley-VCH, 2019.
2. **Sam-Shajing Sun and Larry R. Dalton**, *Introduction to Organic Electronic and Optoelectronic Materials and Devices*, CRC Press, 2020.
3. **S. Ogawa**, *Organic Electronics: Materials and Devices*, Springer, 2020.

Reference book:

1. **Wenping Hu**, *Organic Optoelectronics*, John Wiley & Sons, 2018.

2. **T. Ross Kelly**, *Molecular Machines*, Topics in Current Chemistry, Springer, 2017.

3. **C. Davis**, *A Journey Through the World of Molecular Machines*, Create Space, 2018.

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1. https://mrcet.com/downloads/digital_notes/ME/IV%20year/Renewable%20Energy%20Sources.pdf
2. https://www.transmittershop.com/blog/vacuum-pressure-gauges-understanding-the-basics/
3. https://research.northeastern.edu/app/uploads/Vacuum_fundamentalspart1.pdf
4. https://www.h-its.org/projects/organic-materials-by-geometrical-design/

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1	Identify and explain the different types of pressure measurement instruments	**K3**
CO2	To utilize imaging and depth profiling techniques to visualize and analyze the composition and structure of materials at the micro-and nano-scale and interpret the resulting data to draw meaningful conclusions.	**K2**
CO3	Apply appropriate analytical techniques to determine the chemical composition and structure of substance and accurately interpret.	**K4**
CO4	Analyze and quantify the concentration of elements in a sample using atomic absorption spectroscopy and interpret the results to draw meaningful conclusion	**K2**
CO5	Apply electro analytical techniques to investigate electrochemical systems, including data collection, analysis and interpretation	**K3**
CO6	To understand a supplement in one or more of the source mixture's constituents	**K4**
CO7	Design and propose experiment to investigate pressure-related phenomena	**K3**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	3	2	2	2
CO2	2	3	2	3	3	2	3	2	2	3
CO3	3	3	2	3	3	2	3	3	3	2
CO4	2	3	2	3	2	3	3	2	3	3
CO5	3	2	3	3	3	3	3	3	3	3
CO6	2	2	3	3	3	3	3	3	2	3
CO7	3	3	2	3	2	3	3	2	3	2
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.4**	**2.6**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

SURFACE CHEMISTRY AND CATALYSIS

L	T	P	O	C
4	0	0	2	4

Courses objectives:

- Understand and describe the fundamental principle of surface chemistry, including adsorption, desorption and surface reactions
- Design and optimize heterogeneous catalytic systems for industrial applications, including petroleum refining, environmental remediation and energy storage.

Unit-I Surface phenomena: **12**

Structure of clean surfaces; Notation of surface structure; Structure of adsorb ate layers; Stepped surfaces; Surface relaxation and Reconstruction; Dynamics and energy

UNIT II Adsorption: **12**

Adsorption: Types of adsorption – adsorption of gases on solids – adsorption of solute from solutions – adsorption isotherms – Freundlich's adsorption isotherm – Langmuir's adsorption isotherm – contact theory – kinetics of surface reactions, unimolecular reactions, Langmuir - applications of adsorption on pollution abatement

Unit-III Catalysis: **12**

Catalyst – types of catalysis – criteria – autocatalysis – catalytic poisoning and catalytic promoters - acid base catalysis – applications (catalytic convertor) – enzyme catalysis– Michaelis – Menten equation.

Unit-IV Heterogeneous Catalysis: **12**

Surface area, pore size and acid Strength measurements; Porous solids; Catalysis by metals, semiconductors and Solid acids; Supported metal catalysts; Catalyst preparation, deactivation and Regeneration. Model catalysts: Ammonia synthesis; Hydrogenation of carbon Monoxide; Hydrocarbon conversion.

Unit-IV Instrumental methods of catalyst characterization: **12**

Diffraction and thermal methods; spectroscopic and microscopic techniques.

Total: 60 hrs

Text books:

1. **Kurt W. Kolasinski**, *Surface Science: Foundations of Catalysis and Nanoscience*, 4th Edition, Wiley, 2016.
2. **C. N. S. Murthy**, *Catalysis: Principles and Applications*, McGraw-Hill Education, 2021.
3. **J. M. Thomas and W. J. Thomas**, *Principles and Practice of Heterogeneous Catalysis*, Wiley-VCH, 2015.

References:

1. **A. S. Bhatti**, *Surface Chemistry: Fundamentals and Applications*, Springer, 2021.

2. **A. Goel**, *Catalysis and Surface Chemistry*, Wiley, 2020.

3. G.A. Somorjai, Y. Li , Introduction to Surface Chemistry and Catalysis, Wiley, 2010.

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1. https://iopscience.iop.org/book/mono/978-1-6817-4954-9/chapter/bk978-1-6817-4954-9ch3
2. https://beckassets.blob.core.windows.net/product/readingsample/286231/9783540005452_excerpt_001.pdf
3. https://physics.uwo.ca/~lgonchar/courses/p9826/Lecture2_SurfaceStructure.pdf

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1	Analyze and apply knowledge of surface phenomena to understand and control surface properties and behaviors.	**K3**
CO2	Apply adsorption principles to design and optimize adsorption systems for industrial applications.	**K2**
CO3	Optimize catalytic systems to enhance reaction efficiency and selectivity.	**K4**
CO4	Evaluate heterogeneous catalytic systems, including catalytic preparation characterization and reaction engineering to achieve and selective catalytic performance in various industrial applications.	**K2**
CO5	Optimize the hydrogenation of carbon monoxide to produce fuels and chemicals through catalytic system design and process optimization.	**K3**
CO6	The ability to apply instrumental methods to real-world problems select appropriate techniques and interpret data to extract useful information	**K4**
CO7	The ability to understand and apply fundamental principles to analyze and optimize energy related systems.	**K3**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	3	2	2	2
CO2	2	3	2	3	3	2	3	2	2	2
CO3	3	3	2	3	3	3	3	3	3	3
CO4	2	2	2	3	2	3	3	2	3	3
CO5	3	3	3	3	3	2	3	3	2	3
CO6	3	2	2	3	2	3	3	3	3	3
CO7	2	3	3	3	3	3	3	2	3	2
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.4**	**2.6**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
4	0	0	2	4

ORGANOMETALLIC CHEMISTRY

Course Objectives:

- The structure, bonding and reactivity of organometallic compounds
- The role of transition metals in catalysis and organic synthesis
- The application of organometallic chemistry in industrial processes, materials science and biological systems

Unit-I Organometallic chemistry of d-block elements: 12

18-electron rule, concept of hapticity; synthesis, structure and bonding of homo and heteroleptic metal-carbonyls, nitrosyls, alkyls, alkenes, allyl, alkynes, and arenes. Synthesis and reactivity of Fischer and Schrock carbenes

Unit-II IR Spectra of organometallic compounds 12

Infrared spectra of metal carbonyls and olefins. Neutral spectator ligands: phosphines and N-heterocyclic carbenes. Metal clusters, Low and high nuclearity clusters, clusters having interstitial atoms, electron counting schemes: polyhedral skeletal electron pair theory/Mingo's rule

Unit-III Structure and Isolobal analogies. 12

Metallocenes and bent-metallocenes. Fluxionality and dynamics in organometallic chemistry

Unit-IV Reactions of organometallic complexes: 12

Substitution, oxidative addition, reductive elimination, insertion and deinsertion. Organometallic compounds of s-block elements: Organo-lithium, beryllium and magnesium compounds

Unit-V Catalysis: 12

Organometallic catalysts, Terminology in catalysis: Turnover, turnover number (TON), turnover frequency (TOF). Hydrogenation, Hydroformylation, Monsanto process, Wacker process, Ziegler-Natta polymerization, C-C coupling reactions, Olefin Metathesis and metathesis polymerization

Total: 60 hrs

Text Books:

1. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, Wiley, 2020.
2. **Gary L. Miessler, Donald A. Tarr, and Robert J. McNeil**, *Inorganic Chemistry*, 6th Edition, Pearson, 2018.
3. **B. D. Gupta and A. J. Elias**, *Basic Organometallic Chemistry: Concepts, Synthesis, and Applications*, 3rd Edition, Universities Press (India), 2018.

Reference book:

1. **L. K. Saini**, *Organometallic Chemistry: Principles and Applications*, 2nd Edition, Springer, 2020.

2. **W. Alcock**, *Organometallic Chemistry*, 2nd Edition, Oxford University Press, 2017.

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1. https://link.springer.com/chapter/10.1007/978-94-010-9681-2_5
2. https://www.bartleby.com/subject/science/chemistry/concepts/organometallic-compounds-of-d-block
3. https://www.worldscientific.com/doi/10.1142/9789811281778_0008

Course Outcomes (CO):

At the end of this course, learners will be able to:

CO1	Explain the fundamental concepts and principles of organometallic chemistry	**K2**
CO2	The analyze of transition metals in catalysis and organic synthesis	**K4**
CO3	The classify of organometallic chemistry in industrial processes, materials science and biological systems	**K4**
CO4	Use IR spectroscopy to characterize and identify organometallic compounds	**K3**
CO5	Understand the applications of these reaction in catalysis and organic synthesis	**K2**
CO6	Design and propose synthetic routes involving organometallic complexes	**K6**
CO7	Identify and explain isolobal relationships between different molecular fragment	**K3**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	3	2	2	2
CO2	2	3	2	3	3	2	3	2	2	3
CO3	3	2	3	3	3	3	3	2	2	2
CO4	3	2	3	3	2	3	3	3	3	3
CO5	2	2	3	3	2	3	3	3	3	2
CO6	2	2	3	3	3	3	3	3	3	3
CO7	3	3	2	3	3	2	3	3	3	3
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.6**	**2.6**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
4	0	0	2	4

NANOMATERIALS

Course Objective:

- To know about the students nanomaterials and Familiarize with recent special nanomaterials,
- To including carbon-based nanomaterials (CNT, graphene), core-shell structures, micro and mesoporous materials, organic-inorganic hybrids, and various nanoproducts.
- To Learn about various chemical methods for synthesizing nanomaterials, such as sol-gel technique, solvothermal methods, co-precipitation hydrolysis, sonochemical method, combustion technique, colloidal precipitation, template process.

UNIT-I Introduction 12

Nanostructured materials-metal-semiconductor-ceramics and composites- size dependent properties - uniqueness in these properties compared to bulk and microscopic solids– nano materials and nanostructures in nature- super hydrophobicity, self-cleaning - antifogging. Recent special nanomaterials - Carbon based nano materials – CNT- graphene- core-shell structures- Micro and Mesopores Materials- Organic-Inorganic Hybrids- ZnO- Silicon -- DNA- RNA- Nanoproducts

UNIT II Preparations Of Nanomaterials 12

Chemical Methods Sol-gel technique – solvothermal methods-control of grain size – co-precipitation hydrolysis – sonochemical method combustion technique – colloidal precipitation template process – growth of nanorods –solid-state sintering- grain growth. Electro deposition - electro spinning technique. Arc method-carbon nano tubes- other nano tubes and nano rods –nano springs –rings chemical routes for nanotubes and nanorods – ion beam induced nanostructures

UNIT III Nano Porous Material 12

Nanoporous Materials Nanoporous materials – Silicon - Zeolites, mesoporous materials - nanomembranes and carbon nanotubes - AgX photography, smart sunglasses, and transparent conducting oxides – molecular sieves – nano sponges.

UNIT IV Electronic And Optical Properties 12

Electronic Properties, Electronic materials, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects, Confinement and transport in nanostructure. Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence, Band gap engineering, Size effect of metal Nano particles, optical properties of semiconductor nano particles.

UNIT V Characterization Techniques Of Nanomaterials **12**

Electron Spectroscopy X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA - Applications to nanomaterials characterization,X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particle size analysis using Scherer formula- Particle Size Analyzer- Ellipsometry- thickness measurements. **Total hours- 60hrs**

Text Books:

1. C. N. R. Rao, A. Murali, and A. K. Cheetham, Nanomaterials: Synthesis, Properties and Applications, 2nd Edition, Wiley, 2018.
2. **S. K. Gupta, R. B. W., and M. P. R.**, *Nanomaterials for Energy and Environmental Applications*, Elsevier, 2017
3. **Y. J. Kim, J. H. Lee, and K. T. Lee**, *Nanomaterials in Drug Delivery: Fundamentals and Applications*, Wiley, 2020.

Reference Book:

1. Paul T. Anastas, Tracy C. Williamson, *Green Chemistry: Frontiers in Benign Chemical Syntheses and Processes*, 2nd Edition, Oxford University Press, 2021
2. **C. S. Barrett and T. B. Massalski**, *Structure of Metals: Crystallographic Methods, Principles, and Data*, 3rd Edition, Pergamon Press, 2018.
3. A. S. Kumar, Transmission Electron Microscopy: Principles and Applications in Material Science, 1st Edition, Springer India, 2017.

Website/Websources:

1. **https://jnanobiotechnology.biomedcentral.com/articles/10.1186/s12951-022-01477-8**
2. **https://www.sciencedirect.com/science/article/abs/pii/B9780125137454500548**

Course Outcomes:

After The completion of this course student will be able to:

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	To understand the fundamentals of nanostructured materials, including metals, semiconductors, ceramics, and composites.	**K2**
CO2:	To learn techniques for controlling grain size and growth, such as solid-state sintering and electrodeposition.	**K3**
CO3:	To explore the applications of nanoporous materials in AgX photography, smart sunglasses, transparent conducting oxides, and nanosponges.	**K3**
CO4:	To learn techniques for the quantitative determination of phases, structure analysis, and determination of lattice parameters.	**K3**
CO5:	To gain knowledge about the electronic properties of nanomaterials, including band structures, Brillouin zones, mobility, resistivity, and relaxation time.	**K4**
CO6:	To analyze recombination centers, Hall effects, and confinement and transport in nanostructures.	**K4**
CO7:	To understand profile analysis and particle size analysis using the Scherrer formula.	**K5**

Mapping of Program outcomes with course outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	3	2	3	2	2	2
CO2	3	3	2	3	3	2	3	2	2	3
CO3	3	3	2	3	3	2	3	2	2	2
CO4	2	2	3	3	2	3	3	3	3	3
CO5	3	2	3	3	3	3	3	3	3	3
CO6	2	2	3	3	3	3	3	3	3	2
CO7	3	3	2	3	2	3	3	3	3	3
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.6**	**2.4**

Assessment Methods:

CAT1	**CAT2**	**Model Exam**	**End Semester Exams**	**Assignments**
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

L	T	P	O	C
4	0	0	2	4

FORENSIC SCIENCE

Course Objective:

- To introduce students to the core concepts and principles of forensic science, including its role in the criminal justice system.
- To Equip students with knowledge and skills for proper crime scene investigation, including evidence collection, preservation, and documentation
- To examine the field of forensic toxicology and the role of chemical analysis in detecting drugs, poisons, and other substances in biological samples.

UNIT-I Forensic Science **12**

Definition, Introduction, Basic Principles & Significance, History & Development of Forensic Science in India and World, Organizational Structure of Forensic Science laboratory, Different divisions and units of Forensic Science Laboratory, Organizational Structure of Forensic Science teaching Institution.

Unit-II Forensic Chemistry and Scope Forensic chemistry **12**

Definition and scope, Introduction to Narcotic drugs, Depressants, stimulants, Hallucinogens their Active components and method of analysis, Designer Drugs & Anabolic steroids, Analytical methods of analysis of IMFL, Country made and Illicit liquor, Denatured spirits and their analysis.

Unit-III Petroleum Products and Edible oil **12**

Analysis of petroleum products Diesel. Analysis of traces of petroleum products in forensic exhibits. Comparison of petroleum products. Adulteration of petroleum products. Edible oil and their adulterants.

Unit-IV Cases Involving Arson Chemistry of fire **12**

Fire scene patterns. Location of point of ignition. Recognition of type of fire. Searching the fire scene. Collection and preservation of arson evidence. Analysis of fire debris. Analysis of ignitable liquid residue. Scientific investigation and evaluation of clue materials. Information from smoke staining. Identification of corrosive acid in Vitriol Throwing cases.

Unit-V Explosives **12**

Classification of explosives – low explosives and high explosives. Homemade explosives. Military explosives. Blasting agents. Pyrotechniques, Synthesis and characteristics of TNT, PETN and RDX. Explosion process. Bomb scene management. Searching the scene of explosion. Post blast residue collection and analysis. Blast injuries. Detection of hidden explosives.

Total hours 60hrs

Text Books:

1. **Richard Saferstein**, *Forensic Science: From the Crime Scene to the Crime Lab*, 5th Edition, Pearson, 2019.
2. **S. M. Gohil**, *Forensic Toxicology*, 1st Edition, Springer India, 2021.
3. **James E. Girard**, *Forensic Science: An Introduction to Scientific and Investigative Techniques*, 5th Edition, CRC Press, 2018.

Reference Book:

1. **V. K. Mahajan**, *Forensic Science in Criminal Investigation and Trials*, 2nd Edition, Eastern Book Company, 2017.
2. **B. K. Dube**, *Textbook of Forensic Toxicology*, 2nd Edition, CBS Publishers & Distributors, 2018
3. **S. M. Gohil**, *Forensic Toxicology*, 1st Edition, Springer India, 2021.

***Website/Websources*:**

1. www.forensic-science-society.org.uk
2. www.journals.elsevier.com/forensic-science-international
3. www.forensic-toxicology.com

Course Outcomes:

After The completion of this course student will be able to:

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	To Understand the scientific methods used in forensic investigations and their role in solving criminal cases.	**K2**
CO2:	To Apply forensic techniques for the collection, analysis, and interpretation of evidence.	**K3**
CO3:	To Analyze various types of forensic evidence, including biological, chemical, and trace evidence, in the context of real-world cases.	**K3**
CO4:	To Understand the importance of ethical and legal considerations in forensic science, including evidence handling, expert testimony, and the judicial process.	**K3**
CO5:	To gain a fundamental understanding of the chemical principles and processes involved in fire, particularly the science of combustion.	**K4**
CO6:	To identify and differentiate between accidental fires and deliberate acts of arson, using forensic techniques and fire behavior analysis.	**K3**
CO7:	To understand the forensic and legal process involved in presenting explosives-related evidence in court.	**K2**

Mapping of Program out comes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	2	2	3	3	3	2	3	2	2	2
CO2	3	3	2	3	3	2	3	2	2	3
CO3	3	3	2	3	3	2	3	2	2	2
CO4	2	2	3	3	2	3	3	3	3	3
CO5	3	2	3	3	3	3	3	3	3	3
CO6	2	2	3	3	3	3	3	3	3	2
CO7	3	3	2	3	2	3	3	3	3	3
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.6**	**2.4**

Assessment Methods:

CAT1	CAT2	ModelExam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

MATERIALS SCIENCE

L	T	P	O	C
2	0	0	1	2

Course Objectives:

- To understand the crystal structure, growth methods and X-ray scattering.
- To explain the optical, dielectric and diffusion properties of crystals.
- To recognize the basis of semiconductors, superconductivity materials and magnets.

UNIT I Crystallography 6

Crystallography: symmetry - unit cell and Miller indices -crystal systems - Bravais lattices - point groups and space groups - X-ray diffraction-Laue equations-Bragg's law-reciprocal lattice and its application to geometrical crystallography. 1.2 Crystal structure–powder and single crystalapplications. Electron charge density maps, neutron diffraction-method and applications.

UNIT II Properties of crystals 6

LEDs – organic, Inorganic and polymer LED materials - Applications. Optical studies - Electromagnetic spectrum (qualitative) refractive index – reflectance – transparency, translucency and opacity. Types of luminescence – photo-, electro-, and injection luminescence. Phosphor, LASER, Nd laser, Garnet Lasers, Photonics-laser skin resurfacing-CO2 laser - lasers in dermatology.

UNIT III Nanomaterials 6

Introduction-role of size, classification - 0D, 1D, 2D, 3D. Synthesis - Bottom–Up, Top–Down, consolidation of Nano powders. Synthesis- Physical and chemical methods - inert gas condensation, arc discharge, laser ablation, sol-gel, solvo-thermal and hydrothermal – CVDtypes, metallo organic, plasma enhanced, and low-pressure CVD. Microwave assisted and electrochemical synthesis. Characterization – SEM, TEM and AFM principle, instrumentation and application.

UNIT IV Special Materials 6

Semiconductor materials – classification-Ge, Si, GaAs, SiC, GaN, GaP, CdS,PbS. Identification of materials as p and n –type semiconductor-Hall effect - quantum and anomalous, Hall voltage - interpretation of charge carrier density. Applications of semiconductors: p-n junction as transistors and rectifiers, photovoltaic and photogalvanic cell.

UNIT V Materials for Renewable Energy Conversion 6

Solar Cells: Organic, bilayer, bulk heterojunction, polymer, perovskite based, hybrid solar cells. Efficiency and limiting factors. Solar energy conversion: lamellar solids and thin films, dye-sensitized photo voltaic cells, coordination compounds anchored onto semiconductor surfaces - Ru(II) and Os(II) polypyridyl complexes. Photochemical activation and splitting of water, CO_2 and N_2. Manganese based photo systems for water-splitting. Complexes of Rh, Ru, Pd and Pt - photochemical generation of hydrogen from alcohol.

Total hours 30hrs

Text Books

1. S. Mohan and V. Arjunan, Principles of Materials Science, MJP Publishers, 2016.
2. **V. R. Raghavan**, *Materials Science and Engineering: A First Course*, 6th Edition, Prentice Hall, 2020.
3. **B. K. Gupta**, *Introduction to Crystallography*, 2nd Edition, CBS Publishers & Distributors, 2018..

Reference Books

1. Elaine A. Moore, Lesley E. Smart, "Solid State Chemistry - An Introduction", 5th Edition, ISBN 9780367135720, 2020 by CRC Press.
2. L. Liu and S. Bashir, Advanced Nanomaterials and their Applications in Renewable Energy, Elsevier Science, 2015.
3. P. M. Sivakumar, V.I. Kodolov, G. E. Zakie, A. K. Haghi, Nanostructure, Nanosystems, and Nanostructured Materials: Theory-Production and Development, Technology.

Web Resources

1. http://xrayweb.chem.ou.edu/notes/symmetry.html.
2. http://www.uptti.ac.in/classroom-content/data/unit%20cell.pdf.
3. https://bit.ly/3QyVg2R

Course Outcomes:

After the completion of this course student will be able to:

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	To understand and recall the synthesis and characteristics of crystal structures, semiconductors, magnets, nanomaterials and renewable energy materials.	**K2**
CO2:	To integrate and assess the structure of different materials and their properties.	**K3**
CO3:	To analyse and identify new materials for energy applications.	**K3**
CO4:	To explain the importance of crystal structures, piezoelectric and pyroelectric mater nanomaterials, hard and soft magnets, superconductors, solar cells, electrodes, LEDs uses, struct and synthesis.	**K3**
CO5:	To design and develop new materials with improved property for energy applications.	**K4**
CO6:	To integrate and assess the structure of different materials and their properties.	**K3**
CO7:	To analyze and recommend various analytical techniques to assess the standard of various nano materials	**K2**

Mapping of Program outcomes with course outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	2	2	3	3	3	2	3	2	2	2
CO2	3	3	2	3	3	2	3	2	2	3
CO3	3	3	2	3	3	2	3	2	2	2
CO4	2	2	3	3	2	3	3	3	3	3
CO5	3	2	3	3	3	3	3	3	3	3
CO6	2	2	3	3	3	3	3	3	3	2
CO7	3	3	2	3	2	3	3	3	3	3
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.6**	**2.4**

Assessment Methods:

CAT1	CAT2	Model Exam	End Semester Exams	Assignments
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓

CHEMISTRY OF CONSUMER PRODUCTS

L	T	P	O	C
2	0	0	1	2

Course Objectives

- To understand the scientific bases for common consumer products.
- To study the functions and applications of consumer products.
- To estimate the standard of various consumer products.

UNIT I Soaps 6

Definition, Saponification of oils and fats, Mechanism of action of soap. Manufacture of soaps, formulation of toilet soaps. Different ingredients used and their functions. Types: Medicated, herbal, hard, soft, shaving soaps and creams - examples. ISI specifications, testing procedures and limits.

UNIT II Detergents 6

Mechanism of action and types. Anionic detergents: Manufacture of LAB (linear alkyl benzene), sulphonation of LAB – preparation of acid slurry, different ingredients in the formulation of detergent powders and soaps, liquid detergents, foam boosters. Cationic and non–ionic detergents: examples. Manufacture and applications - ethylene oxide condensate. Comparison of soaps and detergents, biodegradation–environmental effects, BIS specifications / limits.

UNIT III Perfumes 6

Introduction, components of a perfume: vehicle, perfumery substances, fixatives. Groups of odorous substances: essential oils, isolates, synthetics and semi synthetics - alcohols, esters, ketones. Methods of extraction from essential oils: expression method, steam distillation, using volatile solvents, adsorption on purified fats and prickling

UNIT IV Skin Preparations 6

Face and skin powders – Ingredients and functions, types, snow and face creams. Antiperspirants, sun-screen – preparations. UV absorbers, skin bleaching agents, depilatories, turmeric and neem powder preparation, vitamin oil. Nail polishes - preparation, nail polish removers, article removers, lipsticks, roughages, eyebrow pencils - ingredients and functions, hazards, ISI specifications.

UNIT V Food Adulteration and Hygiene 6

Adulterants: Common adulterants in different foods–milk and milk products, vegetable oils and fats, spices and condiments, cereal, pulses, sweetening agents and beverages, contamination with toxic chemicals–pesticides and insecticides, principles involved in the analysis of detection and prevention of food adulteration.

Methods of food preservation and processing, food deterioration. Quality Control: Specifications and standards: FSSAI, Portable Format for Analytics (PFA), Fruit Product Order (FPO), Food and Drug Administration (FDA), drug license, World Health Organisation (WHO) standards, Indian Standards Institution (ISI) specifications, packing and label requirements, essential commodities act, consumer protection

Total hours 30hrs

Text Books

1. M. Gopala Rao and Marshall Sittig, Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, Affiliated East-West Press, 2018.

2. **S. M. M. F. Ali**, *Handbook of Cosmetic Science and Technology*, 3rd Edition, CRC Press, 2019.

3. R. S. N. Pillai, The Chemistry of Cosmetics, 1st Edition, Universities Press, 2017.

Reference Books

1. **K. Bagavathi Sundari**, *Applied Chemistry*, 2nd Edition, MJP Publishers, 2020.

2. **Srinivasan Damodaran and Kirk L. Parkin**, *Fennema's Food Chemistry*, 6th Edition, CRC Press, 2020.

3. **Richard W. Hartel**, *Introduction to Food Science and Technology*, 1st Edition, Springer, 2017.

Web Resources

1. https://bit.ly/3ya27J6

2. https://bit.ly/3b42Vpx

3. https://bit.ly/3OLZyT1

Course Outcomes:

After The completion of this course student will be able to:

Course Outcomes (CO): At the end of this course, learners will be able to:

CO1:	To understand the scientific bases of consumer products.	**K2**
CO2:	To apply the basic concepts in interpreting the functions of consumer products.	**K3**
CO3:	To analyze and recommend various analytical techniques to assess the standard of various consumer products	**K3**
CO4:	To appraise the adverse impact of adulterants used in the food materials and consumer prod	**K3**
CO5:	To summarize and validate the effect of various chemical constituents used in consumer products.	**K4**
CO6:	Appraise the adverse impact of adulterants used in the products.	**K3**
CO7:	To analyze and recommend various analytical techniques to assess the standard of various commercial products.	**K2**

Mapping of Program outcomes with course outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	3	2	3	2	2	2
CO2	3	3	2	3	3	2	3	2	2	3
CO3	3	3	2	3	3	2	3	2	2	2
CO4	2	2	3	3	2	3	3	3	3	3
CO5	3	2	3	3	3	3	3	3	3	3
CO6	2	2	3	3	3	3	3	3	3	2
CO7	3	3	2	3	2	3	3	3	3	3
Average	**2.6**	**2.6**	**2.4**	**3**	**2.8**	**2.4**	**3**	**2.4**	**2.6**	**2.4**

Assessment Methods:

CAT1	**CAT2**	**Model Exam**	**End Semester Exams**	**Assignments**
✓	✓	✓	✓	✓
Quiz	**MCQ**	**Projects**	**Seminars**	**Demonstration/ Presentation**
			✓	✓