M. Sc Chemistry Programme

Under

Learning Outcomes based Curriculum Framework (LOCF)

(For those students admitted during the Academic Year 2025-26 and after)

SYLLABUS

Since 1919

POST GRADUATE AND RESEARCH DEPARTMENT OF CHEMISTRY

(DST-FIST Sponsored Department)

NATIONAL COLLEGE (Autonomous)

(Nationally re-accredited at 'A' Level by NAAC)

College with Potential for Excellence by UGC,

DBT-STAR & DST-FIST Sponsored College

Tiruchirappalli-620 001

Post Graduate and Research Department of Chemistry

College

Vision: To offer quality higher education to the younger generation, especially from rural India, who are economically and socially backward, to liberate themselves from prejudice, oppression and ignorance and to gain knowledge for their bright future.

Mission:

- To ignite the young minds with lofty ideals and inspire them to achieve excellence in the chosen field.
- To facilitate individual growth of students, with accent on character building, through co-curricular and extra-curricular activities.
- To encourage the students to take up research and help them reach global standards.
- To provide a congenial atmosphere to study and to learn with infrastructural facilities of high standards.
- To instill in the minds of the students, a sense of Nationalism and to train them in social awareness.

Department

Vision:

The Chemistry Department is dedicated

- To develop a Centre of Excellence for teaching as well as research at par with national and international standards.
- To prepare the students of chemistry in such a way that they are self-reliant, highly informative and a better candidate in the demanding and ever-changing world.
- To prepare the knowledgeable graduates for careers in academia, industry and government.
- To create a better everyday life for the students and we help the students to realize their full potential.

Mission:

- To develop wholesome and efficient student who will cause transformation in society through a study of chemistry.
- To extend the best student support services by making them comprehensive and by evolving a curriculum relevant to student community and society.
- To encourage students to face IIT-JAM, CSIR-NET, GATE, SET and other competitive examinations.
- To invite scientists from National/International laboratories for lectures of global standard.
- To provide high quality education through effective teaching – learning process for their pursuing high-quality teaching, learning, research, and service.

- To provide an educational environment where students can realize their full potential in chemistry and attain quality education to face the challenges of the future.
- To make the present-day students who are the citizens of tomorrow more productive and successful by eliminating the barriers to opportunities.
- To make the students use the information gained in the classroom in their practical life, which is always challenging, by helping them to develop their skills.
- To shape the minds of the students so that they create a new future.
- To make the future teachers disseminate the educational content effectively and globally.
- To set the standards of excellence by helping them reach their full potential.

Goals:

1. To improve students' basic knowledge of chemistry and to develop skills of scientific inquiry to design and carry out scientific investigations and evaluate scientific evidences to draw conclusions.
2. To make the students to think analytically, critically and creatively to solve problems, judge arguments, and make decisions in scientific and other contexts so that they can start a career in chemical industries.
3. To give training to develop inquiring minds and curiosity about science.

Programme Educational Objectives (PEOs)

1. Graduates will be able to accomplish professional standards in the global environment.
2. Graduates will be able to uphold integrity and human values.
3. Graduates will be able to appreciate and promote pluralism and multiculturalism in working environment.

National College (Autonomous), Tiruchirappalli

(PG Programme Outcomes)

Master of Science (M.Sc.)

PO1: On completion of this programme, the graduates will get enhanced career prospects, improved problem solving and decision-making skills.

PO2: Graduates will have good personal, professional and intellectual abilities in their respective disciplines.

PO3: Graduates would have received good professional and hands on training in their respective field of study which makes them job-oriented Post Graduates.

PO4: Graduates will be able to do academic research in their specialized disciplines using all modern methods and technology.

PO5: Graduates will have the ability to apply professional ethics, accountability, and equity in all their endeavors.

PO6: Graduates will have the ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge

PO7: Graduates will be able to qualify in NET/SET/JRF/CSIR and other academic competitive examinations.

M.Sc., Chemistry

Programme Specific Outcomes

PSO1: Learn, understand and apply the fundamental knowledge of the basic principles in various fields of Chemistry to solve every day problems like softening of hard water, cleaning, purification of water, etc.

PSO2: Provide theoretical background and develop practical skills for analyzing materials using modern analytical methods and instruments and the students will become technically sound to handle the advanced analytical instruments.

PSO3: Understand the background of organic reaction mechanisms, complex chemical structures, and instrumental method of chemical analysis, molecular rearrangements and separation techniques.

PSO4: Appreciate the importance of various elements present in the periodic table, coordination chemistry, in living systems and structure, properties, application of molecules, enzymes, proteins and structural determination of complexes using theories and instruments.

PSO5: Gather attention about the physical aspects of atomic structure, dual behavior, reaction pathways with respect to time, various energy transformations, significance of electrochemistry using their symmetry.

PSO6: Apply various aspects of chemistry like chromatography in natural products isolation, pharmaceuticals, dyes, textiles, polymers, petroleum products, forensic science etc. and also to develop interdisciplinary approach of the subject.

PSO7: Carry out experiments in the area of organic analysis, estimation, separation, derivative

process, inorganic semi micro analysis, preparation, conductometric and potentiometric analyses.

PSO8: Contribute to the nation in the capacity of chemist or as innovator by taking up research career and to pursue Ph.D programme.

PSO9: Become professionally skilled for enormous job opportunities at all level of chemical, pharmaceutical, food products, life oriented material industries and synthetic division of polymer industries & allied division.

PSO10: Appreciate the role of supramolecular chemistry in the development of nanoscience and technology and in the fabrication of supramolecular devices.

PSO11: Clear CSIR-NET examination and competitive exams conducted by service commissions.

PSO12: Develop an understanding of eco-friendly chemical processes and impact of chemistry on health and environment.

GRADUATE ATTRIBUTES:

1. **Academic Excellence:** They will have a promising career in academics, research institutes both in India and abroad.
2. Students will be able to apply very well their knowledge in the design and manufacture of compounds and become entrepreneurs.
3. **Communication skills:** Assignment writing develop all sorts of skills including critical thinking, creativity, and written communication.
4. Students will be able to communicate very well about their scientific findings both orally and written and in ICT formats.
5. **Critical Thinking:** They will be able to think rationally and draw logical conclusions.
6. **Problem Solving:** Students can become leaders of associations, which require finding solutions to problems faced by public.
7. **Analytical Reasoning:**
8. **Design and Development skills**
9. **Individual and team work**
10. **Technology, competency**
11. **Morals and Ethics**
12. **Global citizenship**
13. **Environmental and sustainability**
14. Lifelong learning
15. Students will learn the application of modern tools and techniques in a multidisciplinary environment.
16. Volunteering demonstrates dedication, time management and civic-mindedness.
17. They can defend their ideas in dialogue with peers, respect others' views and perspectives.
18. Participating in individual and team sports builds leadership and team working skills.
19. Students will be to mix with a broad set of people, which will prove to be particularly useful whenever they are required to work within, and manage a fairly diverse team.
20. Submitting the assignment notebooks, practical notebooks, record notebooks in time illustrates the ability to priorities tasks and manage their time effectively.

21. Organizing association meetings and delivering talks to groups shows the ability to communicate clearly and present ideas confidently and confidence. It also helps in developing organization and interpersonal skills.
22. Group practical offers the chance to gain teamwork skills like negotiation, compromise and cooperation.

BLOOM'S TAXONOMY BASED ASSESSMENT PATTERN

K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** - Create

1. Theory Examination - Part I, II & III

CIA Test -I Question Pattern:

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2 Q1 to Q10	A (MCQ)	10 X 1 = 10	Objective Multiple-Choice Questions (4 Questions from each unit)	50
K2, K3 Q11 to Q16	B (4 out of 6)	4 X 5 = 20	Descriptive Answers	
K4, K5 & K6 Q17 to Q19	C (2 out of 3)	2 X 10 = 20	Detailed Answers	

CIA Test -II and End Semester Examination Question Pattern:

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2 Q1 to Q20	A (MCQ)	20 X 1 = 20	Objective Multiple-Choice Questions (4 Questions from each unit)	75
K2, K3 Q21 to Q25	B (Either/or type) ONE question from each unit	5 X 5 = 25	Descriptive Answers (Either/or type) (One question from each unit	
K4, K5 & K6 Q26 to Q30	C (3 out of 5)	3 X 10 = 30	Detailed Answers (One Question from each unit)	

NATIONAL COLLEGE (AUTONOMOUS), TRICHY-620 001
PG & RESEARCH DEPARTMENT OF CHEMISTRY
Programme: M.Sc. Chemistry, (CBCS and Outcome-Based Education (OBE)
(APPLICABLE TO THE CANDIDATES ADMITTED FROM THE ACADEMIC YEAR 2025-2026)

SEM	CODE	COURSE	COURSE TITLE	INSTRUCTION HOURS/ WEEK	CREDIT	EXAM HOURS	EXAMS		TOTAL
							Internal	External	
I	P25CH1	Core-I	Inorganic Chemistry – I	6	5	3	25	75	100
	P25CH2	Core-II	Organic Chemistry-I	6	5	3	25	75	100
	P25CH3	Core-III	Physical Chemistry-I	6	5	3	25	75	100
	P25CH4P	Core-IV	Inorganic Chemistry Practical's	6	5	6	25	75	100
	P25CH5E	Core Based Elective-I	(A) Principles of Chemical Processes (B) Nanomaterials and Nanotechnology (C) Industrial Chemistry	6	3	3	25	75	100
			Total	**30**	**23**				**500**
II	P25CH6	Core-V	Inorganic Chemistry – II	6	5	3	25	75	100
	P25CH7	Core-VI	Organic Chemistry-II	6	5	3	25	75	100
	P25CH8P	Core- VII	Physical Chemistry Practical's	6	5	6	25	75	100
	P25CH9E	Core Based Elective-II	(A) Material Science (B) Green and Environmental Chemistry (C) Research Methodology	6	3	3	25	75	100
	P25CH10E	Core Based Elective-III	(A) Bio-Inorganic Chemistry (B) Polymer Chemistry (C) Spectrometric Techniques	6	3	3	25	75	100
			Total	**30**	**21**				**500**
III	P25CH11	Core-VIII	Inorganic Chemistry – III	6	5	3	25	75	100
	P25CH12	Core-IX	Organic Chemistry-III	6	5	3	25	75	100
	P25CH13	Core-X	Physical Chemistry-II	6	5	3	25	75	100
	P25CH14P	Core-XI	Organic Chemistry Practical's	6	5	6	25	75	100
	P22CH15E	Core Based Elective-IV	(A) Solid State Chemistry (B) Medicinal Chemistry (C) Smart Materials in Emerging Technology	6	3	3	25	75	100
			Total	**30**	**23**				**500**
IV	P25CH16	Core–XII	Inorganic Chemistry – IV	6	5	3	25	75	100
	P25CH17	Core-XIII	Organic Chemistry-IV	6	5	3	25	75	100
	P25CH18	Core-XIV	Physical Chemistry-III	6	5	3	25	75	100
	P25CH19E	Core Based Elective-V	(A) Supramolecular Chemistry (B) Dyes and Pigments (C) Analytical Chemistry	6	3	3	25	75	100
	P25CHP20	Project	Project Work	6	5	-	75	25	100
			TOTAL	**30**	**23**				**500**
			GRAND TOTAL	**120**	**90**				**2000**

Programme Code	Course Title				Course Code
CHYPG1985	INORGANIC CHEMISTRY – I				P25CH1
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	I	Lecture	6	5

Course description

This course offers a complete study of Main Group elements and clusters, bonding and semiconductors. Techniques in Solid State Chemistry, explores the crystalline state, crystal structures, characterization methods, solid-state synthesis, and their applications. Inner transition elements focus on unique electronic configurations, properties, and applications of lanthanides and actinides. A broad introduction to radioactivity, encompassing its principles, and types of decay and applications.

Objectives of the course

- To study the chemistry and structure of Boron and Sulphur chain compounds and principles of acids and bases.
- To know the structure of ionic compounds and features of semiconductors.
- To get the knowledge of crystal systems by X-ray diffraction methods.
- To understand the properties and applications of lanthanides and actinides.
- To provide knowledge about nature, types and applications of radioactive materials

Course Outline

UNIT-I: Main Group Elements and Clusters (18 hours)

Main Group Elements: Hydrides, oxoacids, nitrides, sulfides – shapes and reactivity. Borane cluster: Structural features of closo, nido, arachano and klado; carboranes, hetero and metalloboranes; Wade's rule to predict the structure of borane cluster; main group clusters (p-block elements) – Polythiazyl - zintl ions and MNO rule. Acid-base concepts and principles (Lewis, Brønsted, HSAB and acid base catalysis)

UNIT-II: Ionic Bonding and Semiconductors (18 hours)

Structure of ionic solids - radius ratio rule (triangle, Td, Oh) – Close packing (BCC, FCC, HCP) – Classification of ionic structures – Ionic compounds of the type AX (ZnS, Nacl, CsCl), AX_2 (CaF_2, TiO_2, SiO_2), Layer Structures (CdI_2, $CdCl_2$, [NiAs]) – Lattice energy. Semiconductors: Band theory – features and its applications, insulators and semiconductors, Intrinsic and extrinsic semiconductors – Alloying types and effects with examples.

UNIT-III: Techniques in solid state chemistry (18 hours)

X-ray diffraction technique: Bragg's law, Powder diffraction method – Principle and Instrumentation; Interpretation of XRD data – JCPDS files, Phase purity, Scherrer formula, lattice constants calculation; Systematic absence of reflections; Electron diffraction

technique – principle, instrumentation and application. Electron microscopy – difference between optical and electron microscopy, theory, principle, instrumentation, sampling methods and applications of XPS and XRF

UNIT- IV: Inner Transition Elements (18 hours)

General Characteristics - Electronic Configuration - Stable oxidation States – Lanthanide Contraction and its consequences – Term symbols for lanthanide ions - Colour and Electronic Spectra - magnetic properties of lanthanide complexes – Comparison of Inner Transition and Transition Metals – Seperation of the lanthanides and actinides (Precipitation, Thermal reaction, Fractional crystallization, Complex formation, Solvent extraction, Valency change, Ion exchange).

UNIT-V: Radioactivity (18 hours)

Structure of the nucleus - Discovery of radioactivity, Types, Properties – Decay processes and modes of decay (Beta, Neutron, Positron emissions, K-electron capture and Proton emission) – half-life of radioactive elements – Bethe's notation, Alpha decay –Nuclear reactions-spallation,stripping and pickup (two more) radioactive disintegration series, types of nuclear reactors – particle accelerators- cyclotron,betatron- application of Radioisotopes.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study

1. J. E. Huheey, E. A. Keiter and R. L. Keiter, "Inorganic Chemistry - Principles of Structure and Reactivity", 4th edn., 1993, Harper Collins College Publishers.
2. F. A. Cotton and G. Wilkinson, "Advanced Inorganic Chemistry" 5th edn., 1988, Wiley- Interscience Publication, New York.
3. D. F. Shriver, P.W. Atkins and C.H. Langford, "Inorganic Chemistry", ELBS. 6th edn., 1990, Oxford University press, England.
4. J. D. Lee "Concise Inorganic Chemistry", Reprint 2018, Fifth edition, Wiley – Blackwell Science Ltd., France.
5. Catherine E Housecroft and Alan G, Sharpe "Inorganic Chemistry", 2nd edn., 2004, BIOS Scientific Publishers.
6. L. W. Azaroff, "Introduction to Solids", 2017, Tata Mcgraw hill publishing company, USA.

Book for Reference

1. K. F. Purcel and J. C. Kotz, "Inorganic Chemistry", 1982, W. G. Saunder's Company, Philadelphia.
2. H. Kaur, "Instrumental methods of Chemical Analysis", 2020, 13th edn., Pragati Prakashan, Meerut.

3. M. C. Day and J. Selbin, "Theoretical Inorganic Chemistry", 2nd edn., 1985, Affiliated East- West Press Pvt. Ltd, New Delhi.
4. G. Singh, "Chemistry Of Lanthanides And Actinides", 2007, Discovery Publishing House.
5. W.E. Jolly, "Modern Inorganic Chemistry", McGraw Hill International edn., 1994, New York.

Website and e- Learning Sources

1. https://books.google.co.in/books?id=rBfolO_rhf8C&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
2. https://www.scribd.com/document/696152122/Chemistry-of-the-F-Block-Elements-Hellen-C-Aspinall-Z-Library
3. https://www.scribd.com/document/425818138/HJ-Arnikar-Nuclear-Chemistry
4. https://pdfcoffee.com/huheey-inorganic-pdf-pdf-free.html

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	describe the types, structures, and reactions of cyclic boron and sulphur and differentiate between acid and base chemistry.	**K1**
CO-2	know the various structures of ionic compounds and describe semiconductor properties.	**K2**
CO-3	learn the essential concepts of several crystal systems using X-ray diffraction techniques.	**K3**
CO-4	study the lanthanide contraction, magnetic properties and separation methods.	**K4**
CO-5	understand fundamental concepts like radioactive decay, half-life, nuclear reactions and radioisotopes.	**K5**
CO-6	study the structure and bonding in clusters and ionic solids, diffraction techniques in solid state, magnetic properties of lanthanide complexes and radioactivity.	**K6**

Semester	Course code	Title of the Course			Hours	Credits
I	P25CH1	Inorganic Chemistry - I			6	5
(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Inorganic Chemistry – I course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Inorganic Chemistry – I course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	ORGANIC CHEMISTRY -I				P25CH2
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	I	Lecture	6	5

Course Description

This course outlines the basic concepts of reactive intermediates and the methods of determining reaction mechanisms, highlighting the importance and basic concepts in stereochemistry, and further provides a comprehensive introduction to natural products chemistry by focusing on the study of the biological importance of alkaloids and terpenes.

Objectives of the course

- To make the students know about the nomenclature of organic compounds by IUPAC rules
- To learn the concepts of various methods of determination of reaction mechanisms and to comprehend the multiple factors that operate in organic reactions.
- To explore molecular symmetry, chirality, and stereo chemical principles.
- To delve into geometric isomerism, and the role in conformation and reactivity relationships.
- To enable the students to understand the importance of Drug dosage and product development

Course Outline

UNIT-I: Reactive Intermediates and Electronic Effects (18 Hours)

1.1. IUPAC nomenclature of alicyclic, bicyclic, and tricyclic compounds

1.2. Reactive Intermediates: Classical and non-classical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, and singlet oxygen- general methods of generation, detection, geometry, stability, and reactivity of intermediates.

1.3. Electronic Effects: Inductive effect, resonance effect – hyper conjugation (Baker Nathan effect), hydrogen bonding (inter and intramolecular), and steric effects.

UNIT-II: Methods of Determining Reaction Mechanisms and Correlation Analysis (18 Hours)

2.1. Kinetics and non-kinetic methods of determination of reaction mechanisms - Thermodynamic and kinetic aspects of organic reactions, energy profile diagrams - spectroscopic studies, isotopic effects - intermediate versus transition states – product analysis and its importance - crossover experiments - isotopic labelling studies.

2.2. Correlation Analysis: Linear Free Energy Relations - Hammett equation - significance - sigma and rho applications and limitations - Taft, Swain-Scott-Grunwald Winstein equations and their applications, classification of solvents.

UNIT-III: Stereochemistry-I (18 Hours)

3.1. Introduction to molecular symmetry and chirality – axis, plane, center, alternating axis of symmetry. Optical isomerism due to asymmetric and dissymmetric molecules with C, N, S based chiral centers. Optical purity, prochirality, enantiotopic and diastereotopic atoms, groups, faces, axial and planar chirality, chirality due to helical shape, methods of determining the configuration.

3.2. Racemi modifications: Racemization by thermal, anion, cation, reversible formation, epimerization, mutarotation. D, L system, Cram's and Prelog's rules: R, S-notations, proR, proS, side phase and re phase Cahn-Ingold Prelog rules, absolute and relative configurations. Configurations of allenes, spiranes, biphenyls, cyclooctene, helicene, binaphthyls, ansa and cyclophanic compounds, exo-cyclic alkylidene-cycloalkanes.

UNIT-IV: Stereochemistry-II (18 Hours)

4.1. Geometrical isomerism: Geometrical isomerism - E, Z - determination of the configuration of geometrical isomers (cyclization, converting into compounds of known configuration, dipole moment, converting into less symmetric compounds – spectroscopic methods) configuration of cyclic and bicyclic ring systems - cis-trans nomenclature of three, four and six-membered substituted cyclic systems - decalins.

4.2. Dynamic Stereochemistry: Quantitative correlation between conformation and reactivity - Winstein-Eliel equation - Curtin Hammet principle - saponification of an ester - esterification of alcohol - chromic acid oxidation of cyclohexanols - neighboring group participation - deamination of 2- amino cyclohexanol.

UNIT-V: Natural product: Alkaloids, Antibiotics & Steroids and Terpene (18 Hours)

5.1. Alkaloids: Biological importance of alkaloids- structural elucidation of Morphine and Reserpine - Vincristine, Adrenaline and Atropine (structure only)

5.2. Antibiotics & Steroids: Chemotherapy - definition LD_{50} - Structural elucidation and synthesis of penicillin, streptomycin - cephalosporin-C. Classification-structural elucidation of cholesterol (synthesis not required), structural elucidation and synthesis of Vitamin D, estrone, progesterone, ergosterol.

5.3. Terpenes: Definition, Classification, isoprene rule, isolation and UV quantification of terpenoids, - biological activity- structure elucidation of zingeberin, camphor.

Teaching Methodology: Chalk & Talk, PPT, videos and demonstration

Books for Study

1. R. Panico, W. H. Powell, L. Jean. C. Richer, "A guide to IUPAC Nomenclature of Organic Compounds", (1993), Jain Inter science.
2. S. C. Pal, "Nomenclature of Organic Compounds", (2008), Narosa Publishing House.
3. D. Nasipuri, "Stereochemistry of Organic Compounds-Principles and Applications", 2nd Ed., New Age International (2005).
4. P. S. Kalsi, "Stereochemistry", Wiley Eastern Ltd, 1990.
5. E. L. Eliel and S. H. Wilen, "Stereochemistry of Organic Compounds", John Wiley, 2008.
6. T. H. Lowry and K. S. Richardson, "Mechanism and Theory in Organic Chemistry", 2nd Ed., Harper and Row, 1981.
7. O. P. Agarwal, "Chemistry of Organic Natural Products", Volume I & II, Goel Publishers, 2014.
8. I. L. Finar, "Organic Chemistry", Volume-II, 5th Ed., (2006).

Books for Reference

1. Carey, F. A., & Sundberg, R. J. (2007). Advanced Organic Chemistry Part-A and B, (5th Ed.). Kluwer Academic / Plenum Publishers.
2. Morris, D. G. (2001). Stereochemistry. RSC Tutorial Chemistry Text 1.
3. Isaacs, N. S. (1987). Physical Organic Chemistry. ELBS, Longman.
4. Eliel, E. L. (2000). Stereochemistry of Carbon Compounds. Tata-McGraw Hill.
5. Finar, I. L. (2004). Organic Chemistry. Vol-1 & 2, (6th Ed.). Pearson Education Asia.
6. Michael B. Smith, J. March, "March's Advanced Organic Chemistry", John Wiley & Sons, 6th Ed., 2007.
7. J. Clayden, N. Greeves, P. Wothers, "Organic Chemistry", Oxford University Press, 2001.

Website and e- Learning Sources

1. https://sites.google.com/site/chemistryebookscollection02/home/organic-chemistry/organic
2. https://www.organic-chemistry.org/
3. https://www.ncbi.nlm.nih.gov/books/NBK482447/
4. https://training.seer.cancer.gov/treatment/chemotherapy/types.html

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire knowledge about IUPAC nomenclature, electronic effects, Reactive Intermediates, determining reaction mechanism, kinetic and non-kinetic methods and Correlation Analysis, organic stereochemistry - geometrical and Optical isomerism, dynamic Stereochemistry and the importance of carbohydrates, antibiotics, steroids, and alkaloids. Identify various sources of drugs and understand drug nomenclature.	**K1**
CO-2	understand the basic concepts of electronic effects, reactive intermediates and their structure and stability, organic stereochemistry, and isomerism -both geometrical and optical isomerism	**K2**
CO-3	apply the electronic effects and elucidate reaction mechanism, categorize organic compounds as R & S notations, E & Z notations, sort out as cis and trans nomenclature of 3,4,6 membered substituted cyclic systems, decalins.	**K3**
CO-4	analyze and interpret molecular structures, understanding the underlying principles of symmetry and chirality. Analyze the principles of drug regulation and control, including the role of pharmacopeias and formularies.	**K4**
CO-5	evaluate the effects of conformation on reactivity, using theoretical and practical approaches to predict and explain stereochemical outcomes in cyclic and bicyclic systems.	**K5**
CO-6	create different routes of drug administration and the need for specific application	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
I	**P25CH2**	**Organic Chemistry – I**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**		**No Correlation**
Level of Correlation	**1**	**3**		**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Organic Chemistry-I course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Organic Chemistry-I course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	PHYSICAL CHEMISTRY - I				P25CH3
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	I	Lecture	6	5

Course Description

This course provides an in-depth exploration of the principles and applications of quantum mechanics, chemical kinetics, and photochemistry. It is designed for students with a strong foundation in physical chemistry and aims to equip them with theoretical and practical knowledge of quantum mechanical systems, reaction kinetics, catalysis, and radiation chemistry.

Objectives of the course

- Understand the fundamental principles and postulates of quantum mechanics and their application to chemical systems.
- Learn approximation methods in quantum mechanics for atomic and molecular systems, including perturbation and variation methods.
- Gain insights into chemical kinetics, reaction rate theories, and the mechanisms of unimolecular and chain reactions.
- Explore fast reaction kinetics, experimental techniques, and homogeneous catalysis in chemical processes.
- Understand the principles of photochemistry and radiation chemistry, including their applications in industry and biology.

Course Outline

Unit-I: Quantum Chemistry: (18 Hours)

1.1 Fundamentals of Quantum Mechanics: Postulates - operator algebra - Expressions – addition, subtraction and multiplication - linear operators, Laplacian, vector, and ladder operators - Quantum mechanical operators for position, linear momentum, kinetic energy, potential energy, total energy and angular momentum. Commutator algebra - evaluation of commutators.

1.2 Applications of Quantum Mechanics: Schrödinger wave equation and its application to simple systems. Particle in a 1D and 3D box - energy quantization - wave function characteristics, uncertainty principle and selection rules. Rigid rotator - rotational energy levels, simple harmonic oscillator, and zero-point energy.

Unit-II: Approximation Methods in Quantum Mechanics (18 Hours)

2.1 Hydrogen Atom and Atomic Structure: Radial wave functions - probability distribution - atomic orbital shapes - term symbols, L-S and J-J coupling schemes, and spectroscopic states.

2.2 Approximation Methods in Quantum Mechanics: First-order perturbation theory - variation method applied to hydrogen and helium atoms - Hartree-Fock SCF method - electron spin - Pauli principle - antisymmetric wave functions - Slater determinants, and approximate wave functions for atoms and molecules.

2.3 Molecular Quantum Mechanics and Chemical Bonding: Born-Oppenheimer approximation - molecular Hamiltonian - VB and MO treatments of hydrogen and diatomic molecules - molecular term symbols - hybridization, and HMO theory for ethylene and butadiene.

Unit-III: Chemical Kinetics (18 Hours)

3.1 Empirical Rate Laws and Theories of Reaction Rates: Empirical rate laws - collision theory and transition state theory, with concepts of potential energy surfaces and kinetic isotope effect.

3.2 Unimolecular and Chain Reactions: Lindemann, Hinshelwood, RRK, RRKM, and Slater's theories of unimolecular reactions. Chain reactions, steady-state approximation, and kinetics of reactions like H_2-Br_2, N_2O_5 decomposition, acetaldehyde decomposition, and H_2-O_2 explosions.

3.3 Reaction Kinetics in Solution and Pressure Effects: Influence of solvent dielectric constant and ionic strength, Bronsted-Bjerrum equation, salt effects, pressure dependence of reaction rates, and volume of activation.

Unit-IV: Fast Reactions and Homogeneous Catalysis (18 Hours)

4.1 Fast Reactions and Experimental Techniques: Introduction to fast reactions, significance, and experimental techniques - flow methods, relaxation methods (T-jump, P-jump), pulse techniques (pulse radiolysis, flash photolysis), shock tube, and molecular beam methods.

4.2 Homogeneous Catalysis and Enzyme Kinetics: Acid-base catalysis, protolytic and prototropic mechanisms. Enzyme catalysis, Michaelis-Menten kinetics, Lineweaver-Burk and Eadie plots, and influence of pH on enzyme activity.

4.3 Surface Reactions and Applications: Activated Rate Theory (ARRT) for surface reactions and industrial applications, including NH_3 synthesis, C_2H_4 hydrogenation, and hydrocarbon cracking.

Unit-V: Photo and Radiation Chemistry (18 Hours)

5.1 Fundamentals of Photochemistry: Absorption and emission of radiation - excited-state properties (dipole moments, pKa, redox potentials), and photophysical processes like fluorescence, phosphorescence, and deactivation pathways. Excimer and exciplex formation - Stern-Volmer equation - electronic energy transfer mechanisms - photosensitization, and chemiluminescence.

5.2 Experimental Techniques in Photochemistry: Light sources, chemical actinometry, quantum efficiency measurement, photosynthesis (PSI & PSII), and photochemical conversion and storage of solar energy.

5.3 Radiation Chemistry and Applications: High-energy radiation sources - interaction with matter - water radiolysis - G-value determination - hydrated electron reactions - radiation chemistry techniques - dosimetry, and applications in biology and industry.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. A. K. Chandra, *Introductory Quantum Chemistry*, 4th Ed., Tata McGraw Hill, 1994.
2. R. K. Prasad, *Quantum Chemistry*, 2nd Ed., New Age International, 2000.
3. N. Levine, *Quantum Chemistry*, 4th Ed., Prentice Hall of India, 1994.
4. D. A. McQuarrie, *Quantum Chemistry*, University Science Books, 1998.
5. K. J. Laidler, *Chemical Kinetics*, 2nd Ed., Tata McGraw Hill, 1975.
6. A. Frost and R. G. Pearson, *Kinetics and Mechanisms*, John Wiley & Sons, 1953.
7. G. Hughes, *Radiation Chemistry*, Oxford University Press, 1973.
8. J. C. Kuriacose and J. Rajaram, Kinetics and Mechanisms Transformations, Macmillan & Co., (1993).

Book for Reference

1. Peter Atkins and Julio de Paula, "Atkin's Physical Chemistry", Oxford Publishers, 2014.

Website and e- Learning Sources:

1. MIT OpenCourseWare - Quantum Chemistry: https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/
2. NPTEL Online Courses - Quantum Chemistry & Chemical Kinetics: https://nptel.ac.in/courses/104103071
3. ChemLibreTexts - Quantum Mechanics: https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Quantum_Mechanics
4. Khan Academy - Chemical Kinetics: https://www.khanacademy.org/science/chemistry/kinetics

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	Recall fundamental postulates of quantum mechanics, chemical kinetics theories, and photochemical principles.	**K1**
CO-2	Explain quantum mechanical operators, approximation methods, reaction rate theories, and enzyme kinetics.	**K2**
CO-3	Solve Schrödinger's equation for simple systems, determine molecular term symbols, and calculate reaction rates.	**K3**
CO-4	Compare different reaction kinetics models, interpret energy distribution in molecules, and analyze photophysical processes.	**K4**
CO-5	Assess the efficiency of quantum mechanical approximations, predict reaction mechanisms, and evaluate catalytic processes.	**K5**
CO-6	Development of photochemical conversion and storage of solar energy	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
I	**P25CH3**	**Physical Chemistry - I**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**		**Medium**	**High**		**No Correlation**
Level of Correlation	**1**		**3**	**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Physical Chemistry - I course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Physical Chemistry - I course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	INORGANIC CHEMISTRY PRACTICAL				P25CH4P
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	I	Practical	6	5

Course description

The practical inorganic chemistry course affords hands-on experience in preparing, characterizing, and analyzing inorganic compounds, focusing on transition metal complexes and exploring their properties through various techniques. Inorganic qualitative analysis will introduce the systematic identification of inorganic compounds and ions through chemical tests. Inorganic quantitative analysis will initiate the quantitative determination of inorganic substances using various analytical techniques.

Course Objectives:

- To learn the separation of ions in a mixture.
- To learn the volumetric estimation of some inorganic cations.
- To learn the gravimetric techniques.
- Preparation of coordination complexes and their characterization by magnetic susceptibility measurements and Infrared, UV / Vis spectroscopic techniques.

Inorganic Qualitative Analysis:

1. Semi-micro qualitative analysis of a mixture containing two common and two rare cations.

Inorganic Quantitative Analysis:

1. Estimation of Copper, Ferric, Nickel, Chromium and Manganese using photoelectric colorimeter.

Titrimetry (V) and Gravimetry (G) (Demonstrations Only)

1. A mixture of solution(s) will be provided for estimation.
2. Cu (V) and Ni (G)
3. Cu (V) and Zn (G)
4. Fe (V) and Zn (G)
5. Fe (V) and Ni (G)
6. Zn (V) and Cu (G)

Preparation of the following compounds

a) Tetramminecopper [II] sulphate.
b) Potassium trisoxalatochromate[III]
c) Potassium trisoxalatoaluminate[III].
d) Tristhioureacopper[I] chloride.
e) Tristhioureacopper[I] sulphate.

Course Learning Outcomes:

1. Students learn the estimation of ions by separating them in a mixture.
2. Students get skill in preparation of coordination compounds, recording their infrared & electronic spectra and interpreting them.

Book for Study:

1. Inorganic Semi-Micro Qualitative Analysis, V.V. Ramanujam, The National Publishing House, Chennai, 1990.

Book for Reference:

1. W.G. Palmer, "*Experimental Inorganic Chemistry*", Cambridge University Press, Cambridge, 1965.
2. V.I. Posypaiko and N.A. Vasiua, "*Analytical Chemistry in Metallurgy*", Mir Publisher, Moscow, 1984.
3. G.H. Jaffery, J. Bassett, J. Mendhan and R.C. Deeny, "*Vogel's Text book of quantitative Chemical analysis*", ELBS, 1997.

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	learn the principles, perform systematic analysis of inorganic mixtures, identify cations and apply concepts like solubility product and common ion effect.	**K1**
CO-2	learn the principles of colorimetric estimation and instrumentation of the photocolorimeter.	**K2**
CO-3	perform calculations, understand titration principles, and apply volumetric methods to real-world problems, including error analysis and data interpretation.	**K3**
CO-4	understand the principles of gravimetric analysis, perform calculations related to gravimetric analysis, and apply these techniques to determine the amount of a substance in a sample.	**K4**
CO-5	get skill in preparation of coordination compounds, recording their infrared & electronic spectra and interpreting them.	**K5**
CO-6	prepare solutions, perform qualitative and quantitative analysis, synthesize inorganic complexes, understand separation techniques, and utilize instruments like colorimeters and spectrophotometers.	**K6**

Semester	Course code	Title of the Course	Hours	Credits
I	P25CH4P	INORGANIC CHEMISTRY PRACTICAL	6	5

(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1								
K2								
K3								
K4								
K5								
K6								
Non-Scholastic								
Total	5	6	4	5	20	5	25	100%

The COs and POs for the Inorganic Chemistry Practical course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Inorganic Chemistry Practical course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	PRINCIPLES OF CHEMICAL PROCESSES				P25CH5E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	I	Lecture	6	3

Course description

This course describes a foundational understanding of chemical engineering principles, focusing on material and energy balances, and introduces the fundamental concepts and calculations used in chemical industries. Also, explores the intersection of chemistry with both industrial processes and environmental issues, covering topics like industrial chemical production, pollution control, and the environmental impact of chemical activities.

Objectives of the course

- To provide a comprehensive understanding of industrial gases and inorganic chemicals.
- To equip a complete perceptive of environmental science and the interconnectedness of segments.
- To analyze pollution sources, design effective treatment systems, and implement sustainable practices.
- To train students with knowledge of energy systems and environmental impacts.
- To identify metal science and technology for sustainable and cost-effective solutions.

Course Outline

UNIT-I: Industrial Gases and Inorganic Chemicals (18 Hours)

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, hydrogen, acetylene, carbon monoxide, chlorine, sulphur dioxide. Inorganic Chemicals: Manufacture, application and hazards in handling the following chemicals: hydrochloric acid, nitricacid, sulphuric acid, caustic soda, commonsalt, bleaching powder, sodium thiosulphate, hydrogen peroxide, potashalum, potassium dichromate and potassium permanganate.

UNIT-II: Environment and its segments (18 Hours)

Ecosystems. Bio geochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone. Major sources of air pollution. Pollution by SO_2, CO_2, CO, NO_x, and H_2S and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal

of sulphur from coal.

UNIT-III: Water Pollution (18 Hours)

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, fertilizer. Sludge disposal.

Industrial waste management: incineration of waste. Water treatment and purification (reverse osmosis, ion exchange). Water quality parameters for wastewater, industrial water and domestic water.

UNIT-IV: Energy and Environment (18 Hours)

Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

UNIT –V: Industrial Metallurgy (18 Hours)

Preparation of metals (ferrous and non-ferrous) and ultra pure metals for semiconductor technology. Biocatalysis Introduction to biocatalysis: Importance in green chemistry and chemical industry.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. De, A.K. Environmental Chemistry: New Age International Pvt., Ltd, New Delhi, 2010.
2. Stocchi.E., Industrial Chemistry, Vol-I,Ellis HorwoodLtd.UK.
3. Sharma,B.K. & Gaur,H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

Book for Reference:

1. Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.`
2. Dara S. S., A Text book of Engineering Chemistry, S. Chand& Company Ltd. New Delhi.
3. Miller G.T., Environmental Science, 11thedition.Brooks/Cole (2006).
4. Mishra, Environmental Studies, Selective and Scientific Books, New Delhi (2005).

Website and e-Learning Sources

1. https://books.google.co.in/books/about/Environmental_Chemistry.html?id=IWW6I3Jdl9oC&redir_esc=y
2. https://archive.org/details/ElementaryPrinciplesOfChemicalProcessesThirdEdition/page/n201/mode/1up
3. https://pdfcoffee.com/qdownload/engineering-chemistry-by-ss-darapdf-pdf-free.html
4. http://egyankosh.ac.in//handle/123456789/28599

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	able to understand the production, properties, applications, and safety aspects of various industrial gases and inorganic chemicals, as well as their role in different industries and environmental considerations.	**K1**
CO-2	gain knowledge of natural processes, the impact of human actions, and skills to address environmental challenges, fostering critical thinking and a commitment to sustainable practices.	**K2**
CO-3	know water quality, treatment processes, and industrial waste management techniques.	**K3**
CO-4	give information about energy systems, environmental impacts, and sustainable practices.	**K4**
CO-5	get an extensive awareness of metal science and technology.	**K5**
CO-6	apply fundamental chemical principles to solve problems, interpret data, and explain outcomes.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
I	**P25CH5E**	**Principles of Chemical Processes**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		3		3	12
K2	1	1	1	1	4		4	16
K3	1	1	1	1	4		4	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	3		3	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Principles of Chemical Processes course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Principles of Chemical Processes course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	NANOMATERIALS AND NANOTECHNOLOGY				P25CH5E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	I	Lecture	6	3

Course Description

This course covers the fundamentals of nanomaterials and nanotechnologies, including synthesis methods, bonding, structure, mechanical, electrical, and thermal properties, and applications in various industries. It explores nanocomposites, characterization techniques, and the role of size in material behavior.

Objectives of the course

- To understand the concept of nanomaterials and nanotechnology.
- To understand the bonding and structure of nanomaterials
- To understand the various types of nanomaterials and their properties.
- To understand the applications of synthetically important nanomaterials.
- To correlate the characteristics of various nanomaterials and nanocomposites by new technologies.
- To design synthetic routes for synthetically used new nanomaterials.

Course Outline

UNIT-I: (18 Hours)

Introduction of nanomaterials and nanotechnologies, Introduction of the role of size, classification- 0D, 1D, 2D, 3D. Concept of Bulk Vs Nano materials. Synthesis, Bottom-Up, and Top-Down, consolidation of nano powders. Features of nanostructures, Background of nanostructures. Techniques in synthesis of nanomaterials, Tools of the nanoscience. Applications of nanomaterials in diagnostics, energy, and ceramic industries.

UNIT-II: (18 Hours)

Bonding and structure of the nanomaterials, predicting the type of Bonding in a Substance, crystal structure. Metallic nanoparticles, Surfaces of Materials, Nanoparticle Size and Properties. Synthesis- Physical and chemical methods - PVD, ball milling, arc discharge, laser ablation, sol-gel, solvothermal and hydrothermal. Microwave-assisted and electrochemical synthesis.

UNIT-III: (18 Hours)

Mechanical properties of materials, theories relevant to mechanical properties. Techniques to study mechanical properties of nanomaterials, adhesion and friction, thermal properties of nanomaterials Nanoparticles: gold and silver, metal oxides: silica, iron oxide and alumina - synthesis and properties.

UNIT-IV: (18 Hours)

Electrical properties, Conductivity and Resistivity, Classification of Materials based on Conductivity, magnetic properties, and electronic properties of materials. Classification of magnetic phenomena. Nano thin films-spin coating, Quantum Dot, epitaxy quantum dot. Semiconductor materials – classification-Ge, Si, GaAs, SiC, GaN, GaP, CdS, PbS. Identification of materials as p and n-type semiconductors.

UNIT-V: (18 Hours)

Nanocomposites. Application of nanoparticles in different fields. Core-shell nanoparticles - types, synthesis, and properties. Nanocomposites - metal-, ceramic- and polymer-matrix composites-applications. Characterization – SEM, TEM and AFM - principle, instrumentation and applications.

Teaching Methodology: Interactive videos, PPT, Demonstration and creations of models

Books for Study

1. Pradeep, T. (2009). Nano: The Essentials-understanding Nanoscience and Nanotechnology, McGraw-Hill Education.
2. Poole, C. P. Jr., & Owens, F. J. (2009). Introduction to Nanotechnology. Wiley.
3. Shah, M. A. & Ahmad, T. (2010). Principles of Nanoscience and Nanotechnology. Narosa Publishing House.
4. Murty, B. S., Shankar, P. R., B. B. Rath, B., & Murday, J. Textbook of Nanoscience and Nanotechnology. University Press-IIM- Series in Metallurgy and Materials Science.
5. Rao, C. N. R., Muller, A., & Cheetham, A. K. (2004). The chemistry of nanomaterials. WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim.

Books for Reference

1. S.Mohan and V. Arjunan, Principles of Materials Science, MJP Publishers, 2016.
2. Arumugam, Materials Science, Anuradha Publications,2007.
3. Giacavazzo et. al., Fundamentals of Crystallography, International Union of Crystallography. Oxford Science Publications, 2010

4. Woolfson, An Introduction to Crystallography, Cambridge University Press, 2012.
5. James F. Shackelford and Madanapalli K. Muralidhara, Introduction to Materials Science for Engineers. 6th ed., PEARSON Press, 2007.

Websites and e-Learning Sources

1. Baig,N, et. at., Mater. Adv.2021, 2, 1821.
2. Manzano, M. et. al., Nanomaterials 2023, 13(12), 1828.
3. http://xrayweb.chem.ou.edu/notes/symmetry.html.
4. http://www.uptti.ac.in/classroom-content/data/unit%20cell.pdf.
5. http://www.nanohub.org/

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire knowledge of nanomaterials' classifications and synthesis techniques.	**K1**
CO-2	Understand and apply the tools of nanoscience for nanomaterial applications, and theories related to mechanical properties of materials. Understand and classify materials based on electrical and magnetic properties.	**K2**
CO-3	apply knowledge of semiconductor materials and analyze their applications in electronic devices and characterization techniques such as SEM, TEM, and AFM.	**K3**
CO-4	analyze different bonding types and structures in nanomaterials, the features and background of various nanostructures, different bonding types and predict structures in nanomaterials.	**K4**
CO-5	Evaluate the applications of nanomaterials and nanotechnologies, physical and chemical synthesis methods of nanomaterials, adhesion, friction, and thermal properties in various nanoparticles.	**K5**
CO-6	create new techniques for synthesizing nanomaterials and innovate new semiconductor materials for electronic applications.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
I	**P25CH5E**	**Nano Materials and Nano Technology**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to Pos	100 %	77 %	77 %	55 %	44 %	33 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Nano Materials and Nano Technology course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Nano Materials and Nano Technology course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	INDUSTRIAL CHEMISTRY				P25CH5E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	I	Lecture	6	3

Course Description

This course offers a comprehensive insight into Industrial Chemistry, covering chemical technology, raw materials, energy sources, and industrial processes. It emphasizes process optimization, safety measures, and sustainability, with real-world case studies on small- and large-scale manufacturing. Students gain practical knowledge of industrial production, hazard management, and sustainable chemical practices, preparing them for careers in the chemical industry.

Objectives of the course

- To introduce the fundamental principles of chemical technology, process classification, reactor design, and unit operations in industrial chemistry.
- To explore the characteristics, sources, and processing of raw materials, along with energy requirements and corrosion prevention in the chemical industry
- To understand the manufacturing processes of small-scale chemical industries, including electro-chemical industries, surface coatings, soaps, detergents, and firework chemicals.
- To study the production, raw materials, composition, and applications of large-scale industrial products such as cement, plastics, rubber, fertilizers, and pesticides.
- To emphasize industrial safety measures, hazard classification, accident prevention, and environmental concerns, with case studies on industrial disasters.

Course Outline

Unit-I: PRINCIPLES OF CHEMICAL TECHNOLOGY (18 Hours)

Introduction – basic principles of chemical technology – importance of chemical technology – classification of technological process – designing and modeling of chemical plants – unit process and unit operations. Basic requirements of industrial reactors – choice and selectivity of reactor – basic principles of homogeneous and heterogeneous processes and reactors with examples.

Unit-II: RAW MATERIALS AND ENERGY FOR CHEMICAL INDUSTRY (18 Hours)

Raw materials – Characteristics of raw materials and their resources – methods of raw material concentration – integral utilization of raw materials. Energy for chemical industry – power and fuels – classification of fuels – coal – fuel gases and liquid fuels – petroleum – cracking – chemical corrosion – types of corrosion and preventive measures.

Unit-III: SMALL SCALE CHEMICAL INDUSTRIES (18 Hours)

Electro-thermal and electro-chemical industries: electroplating – surface coating industries – oils, fats and waxes – soaps and detergents – cosmetics. Match industries and Fire Works: Manufacture of some industrially important chemicals like potassium chlorate, potassium nitrate, barium nitrate and red phosphorous –metal powders.

Unit-IV: LARGE SCALE CHEMICAL INDUSTRIES (18 Hours)

Manufacturing process – raw materials – composition and uses of products in Portland cement – ceramics – plastics, synthetic fibres –synthetic rubber – fertilizers – insecticides and pesticides – photo film industries – commercial aspects of starting an industry

Unit-V: INDUSTRIAL SAFETY (18 Hours)

Safety signs and colours used in industries – Industrial Hazards and Accidents – Classification of Hazards – Physical, chemical Biological, Ergonomic and stress Hazards – 2805 Causes, prevention and control – case study on industrial accidents – Bhopal gas Tragedy – Heat stress – sources and control – Noise pollution in industry – sources and control.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. Mukhlynov (ed.), Chemical Technology, Vol.1, Mir Publication, Moscow, III edn., 1979.
2. A. K. De, Environmental Chemistry, Wiley Eastern Ltd., II edn., Meerut 1989, Chs, 5 – 7.
3. R.K. Goel, Process know-how and material of construction for Chemical Industries, S.B. Publ., Delhi, 1977.

Book for References:

4. B.N. Chakrabarthy, Industrial Chemistry, Oxford and IBH Publ., New Delhi, 1984.
5. R. Norris Shreve and J.A. Brink, Jr. Chemical Process Industries, IV edn., McGraw Hill, Tokyo, 1977.
6. Industrial Safety and Environment – A.K. Gupta – University Science press, New delhi.

Websites and eLearning Sources

1. https://d5ofvi41ggben.cloudfront.net/e6472fbd-11a6-4778-9d1d-1aaac3e00214-1571831418547-chemical-technology.pdf

Course Outcome		
CO. No.	CO-Statement On successful completion of this course, students will be able to	**Cognitive Level (K-Level)**
CO-1	Understand the fundamental principles of chemical technology, including unit processes, unit operations, and reactor design.	**K1**
CO-2	Explain the characteristics, processing, and utilization of raw materials and energy sources in the chemical industry.	**K2**
CO-3	Analyze the manufacturing processes of small-scale chemical industries such as electrochemical, surface coating, and consumer product industries.	**K3**
CO-4	Evaluate large-scale industrial processes involving cement, ceramics, plastics, synthetic materials, fertilizers, and pesticides.	**K4**
CO-5	Demonstrate awareness of industrial safety measures, hazard classification, accident prevention, and environmental concerns.	**K5**
CO-6	Apply knowledge from industrial chemistry to real-world problems, emphasizing process optimization and sustainability.	**K6**

Semester	**Course code**	**Title of the Course**	**Hours**	**Credits**
I	**P25CH5E**	**Industrial Chemistry**	**6**	**3**

CO'S	**Programme Outcome (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	3	3	0
CO2	9	9	6	3	3	0
CO3	9	9	9	6	3	3
CO4	9	9	6	9	6	3
CO5	9	9	6	3	9	0
CO6	9	9	6	6	3	6
Weightage	54	54	42	39	27	12
Weighted % of Course Contribution to POs	100 %	100 %	77 %	72 %	50 %	22 %

Mapping Correlation	**Low**	**Medium**	**High**	**No correlation**
Level of Correlation	**1**	**3**	**9**	**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K - Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO1/K1	PO1, PO2,PO3, PO4	PO5, PO6	-	-
CO2/K2	PO1, PO3, PO4	PO2, PO5, PO6	-	-
CO3/K3	PO1, PO2,PO3,	PO4, PO5	PO6	-
CO4/K4	PO1, PO2, PO5	PO4, PO6	PO3	-
CO5/K5	PO1, PO2	PO3, PO4, PO5, PO6	PO2, PO6	-
CO6/K6	PO1, PO2	PO3, PO4, PO5, PO6	-	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1	1	4	3	7	12 %
K2	1	1	1	1	4	4	8	16 %
K3	1	2	1	1	5	5	10	20 %
K4	1	1	1	1	4	2	6	12 %
K5	1	1	1	1	4	2	6	12 %
K6	1	1	1	1	4	2	6	08 %
Non Scholastic	-	-	-	-	-	5	5	20 %
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Industrial Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Industrial Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	INORGANIC CHEMISTRY - II				P25CH6
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	II	Lecture	6	5

Course description

This course recommends an entire study on coordination, organometallic and bioinorganic chemistry. Coordination Chemistry explores structure, bonding, reactivity, and applications of metal complexes including catalysis, analytical chemistry, and medicine. Organometallic chemistry focus on the unique properties of transition metals as catalysts and their role in organic synthesis, covering structure, bonding, reactivity, and applications. Bioinorganic chemistry explores the vital roles of metal ions in biological systems with a focus on enzymatic reactions and electron transfer.

Objectives of the course

- To understand the key features and various theories of coordination compounds.
- To describe the stability of metal complexes, types of isomers and reaction mechanism in coordination compounds.
- To study the various types of organometallic reactions.
- To provide an extensive knowledge of organometallic catalysts.
- To learn the biological role and mechanism of bioinorganic complexes.

Course Outline

UNIT-I: Theories Principles and Characteristics of Coordination Compounds

(18 Hours)

Nomenclature of coordination compounds - structure and isomerism, theories of bonding (VBT, CFT, and MOT) – limitations of VBT - CFSE - strong field and weak field splitting - calculation of CFSE - splitting in tetrahedral symmetry - only weak distortions - splitting pattern in various symmetries - factors affecting the magnitude of splitting (10 Dq) - Spectrochemical series - Jorgenson's relation - evidences for CFT - magnetism and colour of transition metal ions - LFT. field - tetragonal symmetry - differences between tetrahedral and tetragonal symmetry - Jahn- Teller distortion - nephelauxetic effect and Racah parameter. Molecular Orbital Theory and energy level diagrams concept of Weak and strong fields, Sigma and pi bonding in octahedral, square planar and tetrahedral complexes.

UNIT-II: Stability and Magnetic properties of the Coordination Complexes

(18 Hours)

Stability of coordination compounds - complex formation in solution - stability constants -

step-wise and overall formation constants - pH metric, and photometric methods of determination of formation constants - factors affecting stability - statistical and chelate effects - forced configuration. Kinetics and mechanism of reactions - labile and inert complexes - ligand displacement reactions - hydrolysis and anation reactions in octahedral and square planar complexes-trans effect - theory and applications - electron transfer reactions - complementary and non-complementary types - inner sphere and outer sphere processes -isomerisation and racemisation - mixed valence complexes - reactions of coordinated ligands - template effects - synthesis of macrocyclic ligands. Magnetic property of complexes: Spin-orbit coupling, effect of spin-orbit coupling on magnetic moments, quenching of orbital magnetic moments.

UNIT-III: Organometallic Chemistry (18 Hours)

Ligand association and dissociation reactions-oxidative addition and reductive elimination reactions. Hapticity - ligand classification - synthesis and structure - uses of typical organometallics in organic synthesis - such as metal alloys and organomercuric compounds in medicine. metal-alkyl, metal-carbonyl, metal-olefin and metal- carbene complexes and metallocenes. 18 electron rule - applications and limitations - isolobal concept - applications to structure - nitrosyl complexes – types and structure - dinitrogen and dioxygen complexes - molecular orbitals of metallocenes. Classification of fluxional organometallic compounds.

UNIT-IV: Catalysis and Coupling Reactions by Organometallic Compounds

(18 Hours)

Hydrogenation of olefins - hydroformylation of olefins - gold-catalyzed addition of carboxylic acids to alkynes - oxidation of olefins to aldehydes and ketones - polymerization of alkenes-Tolman catalytic loops- cyclooligomerisation of acetylene - Fischer-Tropsch synthesis - epoxidation - metathesis - carbonylation of methanol.

UNIT-V: Bioinorganic Chemistry (18 Hours)

Metalloporphyrins – Hemoglobin and Myoglobin - Ion (Na^+ and K^+) transport, oxygen binding, transport and utilization, electron transfer reactions - Bohr's Effect – Poisoning effect of CO and other ligands - Cytochromes (Cytochrome P-450) - Catalases and Peroxidases - Iron-Sulphur Proteins (Ruberodoxin, Ferredoxins: Fe_2S_2, Fe_3S_4, Fe_4S_4) - nitrogen fixation. Iron Storage and Transport: Ferritin and Transferrin, Siderophores. Photosynthesis - Vitami B_{12}. Metalloenzymes containing Mo, Fe, Co, Cu and Zn.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Books for Study

1. J. E. Huheey, E. A. Keiter and R. L. Keiter, "Inorganic Chemistry - Principles of Structure and Reactivity", 4th edn., 1993, Harper Collins College Publishers.

2. D. F. Shriver, P.W. Atkins and C.H. Langford, "Inorganic Chemistry", ELBS. 6th edn., 1990, Oxford University press, England.
3. W. U. Malik, G. P. Tuli and R. D. Madan, "Selected Topics in Inorganic Chemistry", 6th edn., 2001, S. Chand & Company Ltd., New Delhi.
4. B. D. Gupta and A. J. Elias "Basic Organometallic Chemistry", 2015, 2nd Edn., Univerisities Press.
5. Ajai Kumar "Organometallic & Bioinorganic Chemistry", 2018, 3rd Edn., Aaryush Education.

Book for Reference

1. G. L. Miessler and D.A. Tarr, "Inorganic Chemistry", 2009, Pearson, Prentice Publishers, Delhi.
2. F. A. Cotton and G. Wilkinson, "Inorganic Chemistry A Comprehensive Text", 5th edn., 1988, Inter science Publishers, New York.
3. Catherine E Housecroft and Alan G, Sharpe "Inorganic Chemistry", 2nd edn., 2004, BIOS Scientific Publishers.
4. W. Kaim and B. Schewederski, "Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life", 4th edn. 2013, John-Wiley and sons, New York.

Website and e- Learning Sources

1. https://www.scribd.com/document/475858000/Physical-Inorganic-Chemistry-A-Coordination-Chemistry-Approach-pdf
2. https://books.google.co.in/books?id=4f9vAAAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
3. https://pdfcoffee.com/ajai-kumar-organometallic-amp-bioinorganic-chemist-pdf-pdf-free.html
4. https://www.scribd.com/document/611982817/5-B-D-Gupta-Elias-Organometallic-Chemistry

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	explain structure and bonding and magnetic properties of coordination compounds.	**K1**
CO-2	discuss the properties and reaction mechanisms of coordination compounds.	**K2**
CO-3	identify bond-to-metal complexes and fundamental reactions in organometallic chemistry.	**K3**
CO-4	establish the operating mechanisms in the catalytic processes via structure-activity relations.	**K4**
CO-5	elucidate the binding and functions of inorganic elements in bioinorganic chemistry.	**K5**
CO-6	describe coordination complexes, organometallic compounds and their catalytic processes and metals in biology.	**K6**

Semester	Course code	Title of the Course			Hours	Credits
II	P25CH6	INORGANIC CHEMISTRY - II			6	5
(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Inorganic Chemistry - II course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Inorganic Chemistry - II course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	ORGANIC CHEMISTRY -II				P25CH7
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	II	Lecture	6	5

Course Description

The main objective of this course is to understand the concepts of substitution and addition reaction their path, feasibility and reaction mechanism. It also enables the study to understand the techniques involved in the determination of reaction mechanism and the application of various molecular rearrangements.

Objectives of the course

- To appreciate the concept of substitution reactions.
- To study addition and elimination reactions and their reaction mechanisms.
- To understand the path, feasibility, and mechanism of a reaction
- To understand the techniques involved in the determination of the mechanism of reactions and applications of various molecular rearrangements
- To enable the student to understand and appreciate the importance of biomolecules.

Course Outline

UNIT-I: Substitution Reaction-I (18 Hours)

1.1. Aliphatic Nucleophilic Substitution: SN1, SN2, SNi mechanisms – stereo chemical factors - effect of substrate structure, leaving group, attacking nucleophile and solvent - neighboring group participation - substitution at allylic and vinylic carbons – ambient nucleophiles.

1.2. Aliphatic Electrophilic Substitution: SE1, SE2, SEi, mechanisms – stark enamine reaction - decarboxylation of aliphatic acids - halogenation of aldehydes and ketones, aliphatic diazonium coupling, diazo transfer reaction, C-Nitrosation.

1.3. Aromatic Nucleophilic Substitution: ArSN1, ArSN2, Benzyne mechanisms - orientation effect of substrate structure, leaving group, attacking nucleophile. Reaction involving aromatic nucleophilic substitution – Von Richter.

UNIT-II: Substitution Reaction and Aromaticity (18 Hours)

2.1. Free radical substitution: mechanism, neighboring group assistance (NGA), reactivity of bridged head, attacking radical**.**

2.2. Aromatic Electrophilic Substitution: Arenium ion mechanism - orientation and reactivity energy profile diagrams - the ipso attack - ortho/para ratio - substitution in thiophene - pyridine.

2.3. Aromaticity: Huckel's rule - effect of aromaticity on bond length, ring current - non-benzenoid aromatic compounds – aromatic character in three, five, seven and eight-membered rings - anti aromaticity - system with 4, 8, 10 p electrons - annulene - sydnones - alternant and non-alternant hydrocarbons.

UNIT-III: Addition reaction (18 Hours)

3.1. Addition to carbon-carbon multiple bonds: Mechanistic and stereochemical aspects of reactions involving electrophilic, nucleophilic, and free radical additions - Orientation and reactivity.

3.2. Reactions involving addition to carbon-carbon multiple bonds: addition of halogens, halogen acids, hypohalous acids, hydroboration, epoxidation, ozonolysis, addition to conjugated dienes. Addition of acrylonitrile, Michael addition

3.3. Nucleophilic addition to carbon hetero atom multiple bonds (carbonyls): Aldol condensation, Claisen condensation, Benzoin condensation, Perkin condensation, Knoevenagal, Stobbes reactions Mannich reaction, Cannizaro reaction, Witting, reduction of carbonyl compounds Wolf- kishner reduction, MPV reduction, Clemmenson reduction, Darzens glycidic ester, Addition to alpha, beta-unsaturated carbonyl compounds- addition of Grignard reagents(1,2 , and 1,4 addition) organo lithium, Diels- alder reaction.

UNIT-IV: Rearrangements (18 Hours)

4.1. Rearrangements to electron-deficient carbon: Pinacol-pinacolone and semi-pinacolone rearrangements -applications and stereochemistry, Wagner-Meerwein, Demjanov, Dienone-phenol, Baker Venkataraman, Benzilic acid and Wolff rearrangements.

4.2. Rearrangements to electron-deficient nitrogen: Hofmann, Curtius, Schmidt, Lossen, Beckmann, and abnormal Beckmann rearrangements. Rearrangements to electron-deficient oxygen: Baeyer-Villiger oxidation and Dakin rearrangements.

4.3. Rearrangements to electron-rich atom: Favorskii, Quasi-Favorskii, Stevens, [1,2]-Wittig and [2,3]-Wittig rearrangements. Fries and Photo Fries rearrangement. Intramolecular rearrangements – Claisen, abnormal Claisen, Cope, oxy-Cope Benzidine rearrangements.

UNIT-V: Vitamins and Enzymes (18 Hours)

5.1. Vitamins: Classification, Biochemical function and structure of vitamin A (Retinol) and B complex, B_1 (Thiamine), B_2 (Riboflavin), B_3 (Nilacin), B_5 (Pantothenic acid), B_6 (Pyridoxamine), B_7 (Biotin) (H), B_9 (Folic acid) and B_{12} (Cobalamine). Vitamin C (Ascorbic acid) D (calcifer). Vitamin E (Tocopherols) and vitamin K.

5.2 Enzymes: Nomenclature -based on substrate, reaction, and classification of enzymes, chemical nature, factors affecting enzyme activity, mechanism of enzyme action-lock and

key, induced fit hypothesis, biological functions of enzymes, applications of enzymes-industrial use.

Teaching Methodology: Interactive videos, PPT, Demonstration and creations of models

Book for Study

1. Jerry March, "Advanced Organic Chemistry (Reactions, Mechanisms, and Structure)", - Wiley, 2005.
2. Thomas H. Lowry and K. S. Richardson, "Mechanism and Theory in Organic Chemistry" Addisson-Wesley, 1988.
3. V. K. Ahluwalia and R. K. Parashar, "Organic Reaction Mechanism", Narosa, 2006.
4. M. Badger, "Aromatic Character", Cambridge University Press, 1969.
5. I. L. Finar, "Organic Chemistry", Volume-II, 5th Ed., (2006).
6. K.S. Mukherjee, "Mechanism of organic reactions" Books & Allied Ltd, Published: 2010. 2nd Ed., 2021.
7. Duls Fathima, L.M. Narayanan, R.P. Meyyan, K. Nallasingam, S. Prasanna Kumar and N. Arumugam, "Biochemistry" 4th edition, SarasPublicat ion, Nagercoil, 2013.
8. J. H. Weil, "General Bio-chemistry" - New Age International, 1997.

Book for Reference

1. Structure and Mechanisms, F. Carey, R. Sundberg, "Advanced Organic Chemistry. Part-A". 4th Ed., Kluwer Publishers, 2000.
2. Michael B. Smith, J. March, "March's Advanced Organic Chemistry", John Wiley & Sons, 6th Ed., 2007.
3. J. Clayden, N. Greeves, P. Wothers, "Organic Chemistry", Oxford University Press 2001.
4. J. Mc. Murry, "Organic Chemistry", Brooks/Cole publisher, 5th Ed., 2000.
5. M. B. Smith, "Organic Synthesis', Academic Press, Elsevier, 3rd Ed., 2010.

Websites and eLearning Sources

1. https://sites.google.com/site/chemistryebookscollection02/home/organic-chemistry/organic
2. https://www.organic-chemistry.org/

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	understand the criteria for aromaticity and differentiate the aromatic electrophilic and nucleophilic substitution reactions. Enzymes and vitamins	**K1**
CO-2	examine the mechanisms of nucleophilic substitution reactions and describe nucleophilic substitution on aromatic rings.	**K2**
CO-3	apply the knowledge of reaction mechanism to aliphatic substitution and elimination and free radical reactions	**K3**
CO-4	assess the concept of aromaticity and classify the reactions on aromatic rings, Enzymes, and vitamins	**K4**
CO-5	predict the suitable reagents for the conversion of selective organic compounds. correlate the principles of substitution, elimination, and addition reactions.	**K5**
CO-6	design a detailed mechanism for rearrangement reactions and addition	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH7**	**Organic Chemistry – II**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**		**No Correlation**
Level of Correlation	**1**	**3**		**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Organic Chemistry-II course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Organic Chemistry-II course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	PHYSICAL CHEMISTRY PRACTICAL				P25CH8P
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	I	II	Practical	6	5

Course Description

This course focuses on experimental techniques in kinetics, phase diagrams, adsorption, and titrations. It covers acid hydrolysis, conductometric and potentiometric titrations, adsorption isotherms, and determination of dissociation constants, along with the study of reaction rates and equilibrium.

Objectives of the course

- Analyze the kinetics of ester hydrolysis to compare acid strengths and determine activation parameters.
- Interpret phase diagrams of binary and ternary systems, including simple eutectic and compound formations.
- Construct adsorption isotherms, applying models like Freundlich to analyze adsorption data.
- Perform polarimetric studies to investigate reaction kinetics, such as sucrose inversion.
- Conduct various conductometric and potentiometric titrations to determine dissociation constants and analyze acid-base equilibria.

List of Experiments:

1. a) Comparison of strength of acids by the study of kinetics of hydrolysis of an ester.
   b) Determination of the velocity constant, energy of activation and Arrhenius parameters for the acid hydrolysis of an ester.
2. a) Study of phase diagram of two components forming simple eutectic.
   b) Study of phase diagram of two components forming compound.
3. Construction of adsorption isotherm for the adsorption of oxalic acid on charcoal using Freundlich isotherm.
4. Study of phase diagram of three components system (Acetic acid, Benzene/$CHCl_3$ and Water)
5. Polarimetric study of the kinetics of acid catalyst inversion of sucrose.
6. Kinetics- potassium persulphate and potassium iodide reaction-Determination of order,effect of ionic strength on rate constant
7. a) Conductometric titration of mixture of weak and strong acids Vs.NaOH

b) Conductometric precipitation titration of $BaCl_2$ with $MgSO_4$ / K_2SO_4 and Displacement titrations

8. Conductometric determination of dissociation constant of weak acid and Verification of Onsager equation.
9. a) Conductometric titration of KCl and KI against $AgNO_3$.
   b) Conductometry-Solubility product of sparingly soluble salts.
10. Potentiometric titrations- a) Acid-alkali titrations
    b) Redox titrations.
    c) Precipitation titrations
11. Potentiometry - Determination of dissociation constant of weak acid and pH of a buffer solution

Book for Study:

1. D.D. Khosala, A. Khosala, V.C. Gard, "*Senior Practical Physical Chemistry*", R. Chand & Co., New Delhi, 1975.
2. B. Viswanathan and P.S. Raghavan, "*Practical Physical Chemistry*", Viva Books Pvt. Ltd., New Delhi, 2008.

Book for Reference:

1. E. Daniels, "*Experimental Physical Chemistry*", International Student Ed., McGraw Hill, 1970.
2. G. Peter Mathews, "*Experimental Physical Chemistry*", Oxford Science Publications,1985.
3. J. B. Yadav, "*Advanced Practical Physical chemistry*", 20th Ed., GOEL publishing House, Krishna Pakashan Media Ltd., (2001).
4. Findlay's "*Practical Physical Chemistry*" Revised and edited by B. P. Levitt 9th Ed., Longman, London, 1985.
5. J. N. Gurtu and R. Kapoor, "*Advanced Experimental chemistry*", Vol. I. Chand & Co., Ltd, New Delhi.

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	recall the principles of kinetic studies and phase diagrams to understand acid strength, reaction rates, and equilibrium in chemical systems.	**K1**
CO-2	comprehend the significance of energy of activation, velocity constants, and Arrhenius parameters in determining reaction rates and mechanisms.	**K2**
CO-3	use conductometric and potentiometric techniques to determine dissociation constants, reaction orders, and solubility products in different titrations.	**K3**
CO-4	interpret experimental data from phase diagrams, adsorption isotherms, and titrations to evaluate chemical properties and reaction behavior.	**K4**
CO-5	assess the effectiveness of different experimental methods (conductometric, potentiometric) in studying reaction kinetics, dissociation, and phase transitions.	**K5**
CO-6	design and perform experiments to investigate the kinetics of reactions, adsorption behaviors, and conductometric titrations, formulating new approaches or improvements based on theoretical knowledge.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH8P**	**Physical Chemistry Practical**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1								
K2								
K3								
K4								
K5								
K6								
Non-Scholastic								
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Physical Chemistry Practical course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Physical Chemistry Practical course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	MATERIAL SCIENCE				P25CH9E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	II	Lecture	6	3

Course description

A materials science course explores the study of crystallography, crystal growth methods, special materials and materials for renewable energy conversion. It will give the fundamental principles and practical applications of materials, focus on the relationship between the structure, properties, and processing methods, with applications across various industries.

Objectives of the course

- To study crystal structures, focusing on lattices, symmetries, diffraction, and their relationship to material properties.
- To give way to understand the principles and techniques in controlling crystal growth and enable them to synthesize materials with desired properties.
- To explain the optical, dielectric and diffusion properties of crystals.
- To recognize the basis of semiconductors, superconductivity materials and magnets.
- To learn about the importance of materials used for renewable energy conversion.

Course Outline

UNIT-I: Crystallography (18 Hours)

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. Crystal structure–powder and single crystal applications. Electron charge density maps, neutron diffraction-method and applications.

UNIT-II: Crystal growth methods (18 Hours)

Nucleation–equilibrium stability and metastable state. Single crystal –Low and high temperature, solution growth– Gel and sol-gel. Crystal growth methods- nucleation–equilibrium stability and metastable state. Single crystal–Low and high temperature, solution growth– Gel and sol-gel. Melt growth - Bridgeman-Stockbarger, Czochralski methods. Flux technique, physical and chemical vapour transport. Lorentz and polarization factor - primary and secondary extinctions.

UNIT-III: Properties of crystals (18 Hours)

Optical studies - Electromagnetic spectrum (qualitative) refractive index – reflectance – transparency, translucency and opacity. Types of luminescence – photo-, electro-, and

injection luminescence, LEDs – organic, Inorganic and polymer LED materials - Applications. Dielectric studies- Polarisation - electronic, ionic, orientation, and space charge polarisation. Effect of temperature. dielectric constant, dielectric loss. Types of dielectric breakdown– intrinsic, thermal, discharge, electrochemical and defect breakdown.

UNIT-IV: Special Materials (18 Hours)

Superconductivity: Meissner effect, Critical temperature and critical magnetic Field, Type I and II superconductors, BCS Theory-Cooper pair, Applications. Soft and hard magnets – Domain theory Hysteresis Loop-Applications. Magneto and gian magneto resistance. Ferro, ferri and antiferromagnetic materials-applications, magnetic parameters for recording applications. Ferro-, Piezo-, and pyro electric materials – properties and applications. Shape memory Alloys-characteristics and applications, Non-linear optics-Second Harmonic Generators, mixing of Laser wavelengths by quartz, ruby and $LiNbO_3$.

UNIT-V: Materials for Renewable Energy Conversion (18 Hours)

Solar Cells: Organic, bilayer, bulk heterojunction, polymer, perovskite based. 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.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. S. Mohan and V. Arjunan, Principles of Materials Science, MJP Publishers, 2016.
2. Arumugam, Materials Science, Anuradha Publications, 2007.
3. Giacavazzo et. al., Fundamentals of Crystallography, International Union of Crystallography. Oxford Science Publications, 2010
4. Woolfson, An Introduction to Crystallography, Cambridge University Press, 2012.
5. James F. Shackelford and Madanapalli K. Muralidhara, Introduction to Materials Science for Engineers. 6th ed., PEARSON Press, 2007.

Book for Reference:

1. M.G. Arora, Solid State Chemistry, Anmol Publications, New Delhi, 2001.
2. R.K. Puri and V.K. Babbar, Solid State Physics, S Chand and Company Ltd, 2001.
3. C. Kittel, Solid State Physics, John-Wiley and sons, NY, 1966.
4. H.P. Meyers, Introductory Solid-State Physics, Viva Books Private Limited, 1998.
5. A.R. West, Solid-State Chemistry and Applications, John-Wiley and sons, 1987.

Website and e-Learning Sources

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 Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	understand fundamental concepts like crystal structures, symmetry, and diffraction, and apply this knowledge to analyze and interpret experimental data.	**K1**
CO-2	know the fundamental principles of crystal growth, various techniques, and their applications, enabling them to synthesize and characterize crystalline materials.	**K2**
CO-3	evaluate optical, dielectric and diffusion properties of crystals.	**K3**
CO-4	explain the importance of crystal structures, piezoelectric and pyroelectric materials, nanomaterials, hard and soft magnets, superconductors, solar cells, electrodes, LED uses, structures and synthesis.	**K4**
CO-5	design and develop new materials with improved property for energy applications.	**K5**
CO-6	assess and recall the synthesis and characteristics of crystal structures, semiconductors, magnets, nanomaterials and renewable energy materials.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH9E**	**MATERIAL SCIENCE**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	**Low**	**Medium**	**High**	**No Correlation**
Level of Correlation	**1**	**3**	**9**	**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Material Science course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Material Science course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	GREEN AND ENVIRONMENTAL CHEMISTRY				P25CH9E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	II	Lecture	6	3

Course Description

Green chemistry course emphasizes the importance of sustainability in designing chemical products and processes that minimize or eliminate the use and generation of hazardous substances promoting environmentally friendly and sustainable chemical practices including minimizing waste generation challenges of agricultural and nuclear pollution.

Objectives of the course

- To learn the need and goals of green chemistry
- To make the students to plan the synthesis of organic compounds in a greener approach.
- To understand the concepts and applications of ionic liquids, PTC, and supercritical CO_2
- To learn about the possible sources of agricultural pesticides, its mode of transport and accumulation and its impacts on human health.
- To improve their knowledge of basic information of radioactive decay and permissible radiation dose.

Course Outline

UNIT-I: Introduction to Green Chemistry (18 Hours)

Green chemistry - Introduction - need for green chemistry - goals of green chemistry and limitations of green, International Green chemistry organization, and Anastas' twelve principles of green chemistry with examples - Designing a green synthesis (tools) - choice of starting materials, solvents, catalysts, reagents. Use of the following in green synthesis with suitable examples: green reagents, dimethyl carbonate, polymer support catalyst. Green solvent- water, deep eutectic solvent, green catalysis, acid catalysis, basic, oxidation catalysis

UNIT-II: Microwave, Ultrasound Assisted Organic Synthesis and Biocatalysts (18 Hours)

Microwave activation - advantages of microwave exposure - Microwave assisted reactions, condensation reactions - oxidation, reduction reactions, multicomponent reactions. **Sonochemistry** - use of ultrasound in organic synthesis (alternate source of energy) – instrumentation, cavitation theory, ultrasound assisted green synthesis and application. Saponification - substitution, addition, oxidation reactions, reductions. **Biocatalysts** in green synthesis - use of biocatalysts in green chemistry - advantages - biochemical

(microbial) oxidation and reduction reactions - Baker's yeast mediated bio-transformation -biocatalyst mediated Baeyer-Villiger reaction.

UNIT-III: Ionic liquids - Phase Transfer Catalyst and Supercritical CO_2 in Green Synthesis (18 Hours)

Ionic liquids - synthesis, physical properties of ionic liquids, - applications in alkylation, epoxidation, Friedel-Crafts reaction, Diels-Alder reactions, Knoevenagel condensations, and Wittig reactions. **PTC** - Definition - advantages, types of PTC reactions - synthesis of PTC, applications of PTC in organic synthesis Michael reaction - alkylation of aldehydes and ketones. Oxidation using H_2O_2, crown ether, esterification. Wittig, generation of dihalocarbene, elimination reaction. **Supercritical CO_2**- phase diagram - uses in extracting natural products, dry cleaning, brominating, Kolbe-Schmidt synthesis -Friedel-Crafts reaction. Dimethyl carbonate as a methylating agent in green synthesis.

UNIT-IV: Agriculture pollution and Waste management (18 Hours)

Pesticides - General aspects of classification in terms of chemical nature and generation wise. Bio-accumulation and bio-magnification of pesticides - Fate of insecticides in the environment and environmental hazards - Toxicity of DDT, gammexene and malathion - Safer pesticides - IPM - Environmental hazards arising from fertilizers - Minimization of environmental problems caused by fertilizers. Waste management: Sources and types of waste, Waste treatment and disposal of waste - integrated waste management (IWM) - supercritical water oxidation (SCWO) of wastes - problems of e-waste and solution for e-waste- Integrated waste management of plastics -illustration of 4R's.

UNIT-V: Radioactive Pollution (18 Hours)

Nature of radioactive emission - units - Radiation from natural sources and Man- made activities - Effects of radiation on human health -Permissible radiation dose - Comparative risk analysis of fossil fuel based power generation versus nuclear power generation - Radioactive fallout -Nuclear winter: Black rain, atmospheric turbidity and effects - Radioactive pollution in land, atmosphere and water - Nuclear waste disposal: Nature, general principles and strategies - Causes and prevention of nuclear reactor accidents - Chernobyl disaster - Three Mile Island disaster.

Teaching Methodology: Lectures, Demonstration, Presentations, and videos

Books for Study:

1. Ahluwalia, V.K. and Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers, 2005.
2. W. L. McCabe, J.C. Smith and P. Harriott, Unit Operations of Chemical Engineering, 7th edition, McGraw-Hill, NewDelhi,2005.

3. J. M. Swan and D. St. C. Black, Organometallics in Organic Synthesis, Chapman Hall,1974.
4. V. K. Ahluwalia and R. Aggarwal, Organic Synthesis: Special Techniques, Narosa Publishing House, New Delhi,2001.
5. A. K. De, Environmental Chemistry, New Age Publications, 2017.

Books for Reference:

1. Paul T. Anastas and John C. Warner, "Green Chemistry", Oxford University Press, Indian Edition, 2008.
2. V. K. Ahluwalia and M. Kidwai, "New Trends in Chemistry", Anamaya Publishers, 2nd Edition, 2007.
3. V. Kumar, "An Introduction to Green Chemistry", Vishal Publishers, 1 Edition, 2007.
4. V. K. Ahluwalia and R. S. Varma, "Green Solvents", for organic synthesis Narosa Publishing, 1st Edition, 2009.
5. V. K. Ahluwalia and Renu Aggarwal, "Organic Synthetic Special Techniques", Narosa, 2nd Edition, 2009.
6. V. K. Ahluwalia, "Green Chemistry - Environmentally Benign Reactions", Ane books, India, 2006.
7. Rashmi Sanghi and N. M. Srivastava, "Environment Friendly Alternatives", Narosa Publishing House, 2003.
8. D. K. Asthana and Meera Asthana, "Environment - Problems and Solutions", S. Chand & Co Ltd.
9. Benny Joseph, "Environmental Studies", Tata McGraw Hill publishing Company Ltd, New Delhi.1st Edition 2009.

Website and e-learning source

1. https://www.organic-chemistry.org/
2. https://www.studyorgo.com/summary.php

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire the knowledge about green chemistry and its applications, the environmental hazards of agricultural and radioactive pollution, about waste management, problems of e-waste and 4Rs	**K1**
CO-2	Understand the goals and principles of green chemistry	**K2**
CO-3	apply the principles and experiment with microwave and ultrasound methods for organic synthesis, make use of the green techniques to solve the problems arising in synthetic organic chemistry	**K3**
CO-4	analyze the environmental hazards of agricultural pesticides and diagnose its impacts on human health	**K4**
CO-5	evaluate the causes of radioactive pollution and recommend new strategies for its prevention	**K5**
CO-6	create new strategies for reducing the pollution and radioactive hazards, design methods to reduce waste and fabricate techniques to dispose waste	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH9E**	**Green and Environmental Chemistry**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %

Mapping Correlation	**Low**	**Medium**	**High**	**No Correlation**
Level of Correlation	**1**	**3**	**9**	**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Green and Environmental Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Green and Environmental Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	RESEARCH METHODOLOGY				P25CH9E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	II	Lecture	6	3

Course Description

This course introduces research methodology in chemistry, covering literature search, scientific writing, AI-assisted manuscript preparation, and ethical research practices. Students gain hands-on experience with databases, chemical drawing tools, and presentation software, while learning to publish research findings and uphold ethical standards in scientific writing.

Objectives of the course

- To introduce the fundamentals of scientific research by understanding its purpose, methodologies, and various research types, enabling students to develop a systematic approach to problem-solving in chemistry.
- To familiarize students with chemical literature and software tools used for literature search, data compilation, and scientific visualization, ensuring efficient retrieval and representation of scientific information.
- To develop scientific writing skills by guiding students in drafting research articles, theses, and reports with appropriate technical communication, formatting, and referencing styles, including the use of AI tools for manuscript preparation.
- To provide a structured understanding of article writing and publication processes, covering essential components such as article structure, experimental data presentation, referencing, and manuscript submission requirements.
- To educate students on ethical guidelines in chemical research, emphasizing responsible authorship, plagiarism prevention, conflict of interest disclosure, safety regulations, and professional integrity in scientific publications.

Course Outline

UNIT I: Scientific Research (18 Hours)

The search for knowledge, purpose of research, scientific method, role of theory, characteristics of research - Types of research: fundamental or pure research, applied research, action research, historical research, experimental research.

UNIT II: Chemical Literature and Drawing and Presentation Software (18 Hours)

Computer search of literature: SciFinder, Chemspider, Pubmed, ChemPort - ScienceDirect, STN International, Journal home pages - A report on literature survey - An overview of selected list of compilation of data: Dictionary of Organic Compounds, Merck Index, CRC

Handbook of Chemistry and Physics, Lange's Handbook of Chemistry - An overview of selected list of synthetic methods and techniques and general treatises: Organic Synthesis, Reagents for Organic Synthesis, Comprehensive Organic Chemistry, Encyclopedia of Reagents for Organic Synthesis. Drawing software: Chemdraw, Chemsketch and Origin Presentation software: LibreOffice, MS-word, excel, and PPT

UNIT III: The Scientific Writing (18 Hours)

Types of research articles- journal articles, monographs, communications, reviews, research reports, theses, Format and writing style of journal articles: - Requirement of technical communications: eliminating wordiness and jargon tautology - redundancy, imprecise words, superfluous phrases - Steps to publishing a scientific article in a journal: types of publications, communications, articles, reviews; when to publish, where to publish, specific format required for submission, organization of the material - abstracts - keywords - highlights - referencing styles, bibliography-journal abbreviations - abbreviations used in scientific writing- drafting manuscript using AI tools.

UNIT IV: Structure of an Article (18 Hours)

Choosing the right article - article preparation - article templates - figures, graphs, images , art covers - table of contents entry - photographs - chemical structures - crystal structure images - article content - Section details & bibliography - Title - Authorship - Abstract - Introduction - Experimental - Results & discussion - Conclusions - Author Contributions (optional) - Conflicts of interest - Acknowledgements- Footnotes - Bibliographic references & notes – experimental reporting requirements - Experimental reporting requirements for submission - Experimental data - Characterization of new compounds - General guidance - Presentation of experimental data - Guide to the presentation of experimental data - X-Ray crystallography - Small molecule single crystal data - CheckCIF - Information for inclusion in the CIF- data sharing - preparing electronic supplementary information - language editing service.

UNIT V: Ethical Guidelines to Publication of Chemical Research (18 Hours)

Ethical Obligations of Authors - Ethical Obligations of Scientists Publishing outside the Scientific Literature - Top 10 Tips for Ethical Authorship - Author List and Co-author Notification - Permissions - Funding Disclosures - Conflict of Interest Disclosure -Plagiarism - Safety and hazards- human and animal welfare - authenticity and professionalism - publication of related work.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study

1. Dominoswki, R. L. (1981). Research Methods. Prentice Hall.
2. Ebel, H. F., Bliefert, C., & Russey, W. E. (1988). The Art of Scientific Writing. VCH, Weinheim.
3. Cain, B. E. (1988). The Basis of Technical Communicating, ACS. Washington, D.C.
4. Kanare, H. M. (1985). Writing the Laboratory Notebook. American Chemical Society: Washington. DC.

Book for References

1. J. S. Dodd, Ed. (1985). The ACS Style Guide: A Manual for Authors and Editors. American Chemical Society: Washington. DC.
2. Gibaldi, J., & Achtert, W. S. (1987). Handbook for Writers of Research Papers (2nd Ed.). Wiley Eastern.
3. Ethical Guidelines to Publication of Chemical Research. ACS publications. (2023). 8. Full guidelines for authors. RSC Journals. (2023).

Website and e-Learning Sources

1. https://pubs.acs.org/pb-assets/documents/policy/EthicalGuidelines1676503020770.pdf
2. https://www.rsc.org/journals-books-databases/author-and-reviewerhub/authors-information/

Course Outcome		
CO. No.	CO-Statement On successful completion of this course, students will be able to	**Cognitive Level (K-Level)**
CO-1	Understand the fundamentals of scientific research, its purpose, methods, and types, including experimental, historical, and applied research.	**K1**
CO-2	Utilize chemical literature databases and software tools for literature search, data compilation, and visualization in research.	**K2**
CO-3	Develop scientific writing skills, including journal article preparation, technical communication, and manuscript drafting using AI tools.	**K3**
CO-4	Structure and organize research articles with appropriate formatting, figures, references, and experimental data presentation.	**K4**
CO-5	Evaluate ethical guidelines in chemical research, ensuring responsible authorship, plagiarism prevention, and conflict of interest disclosure.	**K5**
CO-6	Apply research methodology principles to real-world chemical research problems, focusing on data analysis, reporting, and publication.	**K6**

Semester	Course code	Title of the Course	Hours	Credits
II	P25CH9E	Research Methodology	6	3

CO'S	Programme Outcome (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	6	3	3	0
CO2	9	9	9	6	3	0
CO3	9	9	6	6	3	3
CO4	9	9	6	9	6	3
CO5	9	9	9	9	9	0
CO6	9	9	6	6	3	6
Weightage	54	54	42	39	27	12
Weighted % of Course Contribution to POs	100 %	100 %	77 %	72 %	50 %	22 %

Mapping Correlation	Low	Medium	High	No correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K – Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/K1	PO1, PO2,PO3, PO4	PO5, PO6	-	-
CO2/K2	PO1, PO3, PO4	PO2, PO5	PO6	-
CO3/K3	PO1, PO2,PO3,	PO4, PO5	PO6	-
CO4/K4	PO1, PO2, PO5	PO4, PO6	PO3	-
CO5/K5	PO1	PO2, PO3, PO4, PO5	PO6	-
CO6/K6	PO1, PO2	PO3, PO4, PO5	PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1	1	4	3	7	12 %
K2	1	1	1	1	4	4	8	16 %
K3	1	2	1	1	5	5	10	20 %
K4	1	1	1	1	4	2	6	12 %
K5	1	1	1	1	4	2	6	12 %
K6	1	1	1	1	4	2	6	08 %
Non Scholastic	-	-	-	-	-	5	5	20 %
Total	5	6	4	5	20	5	25	100%

The COs and POs for the Research Methodology course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Research Methodology course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	BIO-INORGANIC CHEMISTRY				P25CH10E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	II	Lecture	6	3

Course description

This course explores the crucial role of metal ions and inorganic molecules in biological systems, covering their functions in enzymes, electron transfer, selective transport and storage, oxygen transport, nitrogen fixation, effects of catalysis and other vital processes, with an emphasis on structure-function relationships and applications in medicine and technology.

Objectives of the course

- To educate the importance of micronutrients for health such as functions, dietary sources, deficiency symptoms, and potential toxicities.
- To provide an understanding of transport proteins, including their structure, function, and mechanisms of action.
- To impart knowledge in the process, its importance in the nitrogen cycle, and its various forms.
- To explore the diverse roles of metals in biological systems, focusing on their use in medicine.
- To understand enzymes, including their structure, function, kinetics, mechanisms of action.

Course Outline

UNIT-I: Essential trace elements (18 Hours)

Selective transport and storage of metal ions: Ferritin, Transferrin and sidorphores; Sodium and potassium transport, Calcium signalling proteins. Metalloenzymes: Zinc enzymes–carboxypeptidase and carbonic anhydrase. Iron enzymes–catalase, peroxidase. Copper enzymes – superoxide dismutase, Plast ocyanin, Ceruloplasmin, Tyrosinase. Coenzymes - Vitamin-B12 coenzymes.

UNIT-II: Transport Proteins (18 Hours)

Oxygen carriers -Hemoglobin and myoglobin - Structure and oxygenation Bohr Effect. Binding of CO, NO, CN– to Myoglobin and Hemoglobin. Biological redox system: Cytochromes-Classification, cytochrome a, b and c. Cytochrome P-450. Non-heme oxygen carriers-Hemerythrin and hemocyanin. Iron-sulphur proteins- Rubredoxin and Ferredoxin-Structure and classification.

UNIT-III: Nitrogen fixation (18 Hours)

Introduction, types of nitrogen fixing microorganisms. 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. Photosynthesis: photosystem-I and photosystem-II-chlorophylls structure and function.

UNIT-IV: Metals in medicine (18 Hours)

Metal Toxicity of Hg, Cd, Zn, Pb, As, Sb. Therapeutic Compounds: Vanadium-Based Diabetes Drugs; Platinum-Containing Anticancer Agents. Chelation therapy; Cancer treatment. Diagnostic Agents: Technetium Imaging Agents; Gadolinium MRI Imaging Agents. temperature and critical magnetic Field.

UNIT-V: Enzymes (18 Hours)

Introduction and properties -nomenclature and classification. Enzyme kinetics, free energy of activation and the effects of catalysis. Michelis - Menton equation - Effect of pH, temperature on enzyme reactions. Factors contributing to the efficiency of enzyme.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. Williams,D.R. –Introdution to Bioinorganic chemistry.
2. F.M. Fiabre and D.R. Williams– The Principles of Bioinorganic Chemistry,RoyolSoceity of Chemistry, Monograph for Teachers-31
3. K.F. Purcell and Kotz., Inorganic chemistry, WB Saunders Co., USA.
4. G.N. Mugherjea and Arabinda Das, Elements of Bioinorganic Chemistry - 1993.
5. R. Gopalan, V. Ramalingam, *Concise Coordination Chemistry*, S. Chand, 2001.

Book for Reference:

1. M.Satake and Y.Mido, Bioinorganic Chemistry- Discovery Publishing House, New Delhi (1996)
2. M.N. Hughes, 1982, The Inorganic Chemistry of Biological processes, II Edition, Wiley London.
3. R. W. Hay, Bio Inorganic Chemistry, Ellis Horwood, 1987.
4. R. M. Roat-Malone, Bio Inorganic Chemistry, John Wiley, 2002.
5. T. M. Loehr, Iron carriers and Iron proteins, VCH, 1989.

Website and e- Learning Sources

1. https://www.pdfdrive.com/instant-notes-in-inorganic-chemistry-the-instant-notes-chemistry-series-d162097454.html

2. https://www.pdfdrive.com/shriver-and-atkins-inorganic-chemistry-5th-edition-d161563417.html

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	identify essential elements, understand their roles in metabolism and cell growth, recognize deficiency and toxicity symptoms, and understand the impact of trace elements on health and disease.	**K1**
CO-2	recognize various types of transport proteins, and understand their functions and mechanisms.	**K2**
CO-3	explain the process, its significance in the nitrogen cycle, and its applications.	**K3**
CO-4	understand the role of metals in biological systems, their applications in therapy and diagnosis	**K4**
CO-5	describe enzyme structure, function, and kinetics and understand enzyme catalysis mechanisms.	**K5**
CO-6	know the roles of inorganic elements in biological systems, metal ion binding to biomolecules, and the mechanisms of biological processes involving metal ions, including enzymatic reactions and electron transfer.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH10E**	**BIO-INORGANIC CHEMISTRY**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**		**No Correlation**
Level of Correlation	**1**	**3**		**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Bio-Inorganic Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Bio-Inorganic Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	POLYMER CHEMISTRY				P25CH10E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	II	Lecture	6	3

Course Description

Polymer chemistry provides the basic concept and bonding in polymers. Outlining the detailed explanation of various types polymerization reactions and its kinetics. It helps to predict the molecular weight determination and degradation of polymers and conducting polymers.

Objectives of the course

- To learn the basic concepts and bonding in polymers.
- To explain various types of polymerization reactions and kinetics.
- To understand the importance of industrial polymers and their synthetic uses.
- To determine the molecular weight of polymers.
- To predict the degradation of polymers and conductivities.

Course Outline

UNIT-I: Characterization, Molecular weight and its Determination (18 Hours)

Primary and secondary bond forces in polymers; cohesive energy, molecular structure, chemical tests, thermal methods, Tg, molecular distribution, stability. Determination of Molecular Mass of polymers: Number Average molecular mass (Mn) and Weight average molecular mass (Mw) of polymers. Molecular weight determination of high polymers by physical and methods.

UNIT-II: Mechanism and kinetics of Polymerization (18 Hours)

Chain growth polymerization: Cationic, anionic, free radical polymerization, Stereo regular polymers: Ziegler Natta polymerization. Reaction kinetics. Step growth polymerization, Degree of polymerization.

UNIT-III: Techniques of Polymerization and Polymer Degradation (18 Hours)

Bulk, Solution, Emulsion, Suspension, solid, interfacial and gas phase polymerization. Types of Polymer Degradation, Thermal degradation, mechanical degradation, photodegradation, Photo stabilizers, Solid and gas phase polymerization.

UNIT-IV: Industrial Polymers (18 Hours)

Preparation of fibre forming polymers, elastomeric material. Thermoplastics: Polyethylene, Polypropylene, polystyrene, Polyacrylonitrile, Poly Vinyl Chloride, Poly tetrafluoro ethylene,

nylon and polyester. Thermosetting Plastics: Phenol formaldehyde and expoxide resin. Elastomers: Natural rubber and synthetic rubber - Buna - N, Buna-S and neoprene. Conducting Polymers: Elementary ideas; examples: poly sulphur nitriles, poly phenylene, poly pyrrole and poly acetylene. Polymethylmethacrylate, polyimides, polyamides, polyurethanes, polyureas, polyethylene and polypropylene glycols.

UNIT-V: Polymer Processing (18 Hours)

Compounding: Polymer Additives: Fillers, Plasticizers, antioxidants, thermal stabilizers, fire retardants, and colourants. Processing Techniques: Calendaring, die casting, compression moulding, injection moulding, blow moulding and reinforcing. Film casting, Thermofoaming, Foaming. Catalysis and catalysts – Polymerization catalysis, catalyst support, clay compounds, basic catalyst, auto-exhaust catalysis, vanadium, heterogeneous catalysis and active centres.

Teaching Methodology: Chalk and Talk, PPT, Videos, ICT

Book for Study:

1. V.R. Gowariker, Polymer Science, Wiley Eastern, 1995.
2. G.S. Misra, Introductory Polymer Chemistry, New Age International (Pvt) Limited, 1996.
3. M.S. Bhatnagar, A Text Book of Polymers, vol-I & II, S.Chand & Company, New Delhi, 2004.

Book for Reference:

1. F. N. Billmeyer, Textbook of Polymer Science, Wiley Interscience, 1971.
2. A. Kumar and S. K. Gupta, Fundamentals and Polymer Science and Engineering, Tata McGraw-Hill, 1978.

Website and e-learning source

1. https://library.fiveable.me/polymer-chemistry
2. https://onlinecourses.nptel.ac.in/noc20_cy21/preview
3. https://www.udemy.com/course/principles-of-polymerchemistry/?srsltid=AfmBOoq_CBc3MvjLIGF-bez4yXgABloMKctZgd57v_5ZhPR4CIFoa_al&couponCode=ST4MT240225A
4. https://www.open.edu/openlearn/science-maths-technology/chemistry/introduction-polymers/content-section-0

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire the knowledge of polymers and analyze various types of polymers	**K1**
CO-2	understand the bonding in polymers	**K2**
CO-3	apply scientific plan and perform the various polymerization reactions	**K3**
CO-4	analyze the observed and record the processing of polymers	**K4**
CO-5	evaluate molecular weight by physical and chemical methods	**K5**
CO-6	Create and interpret the experimental data scientifically to improve the quality of synthetic polymers.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH10E**	**Polymer Chemistry**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K – Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Polymer Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Polymer Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	SPECTROMETRIC TECHNIQUES				P25CH10E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	I	II	Lecture	6	3

Course Description

This course delves into molecular spectroscopy techniques—including microwave, infrared, Raman, electronic, UV-visible, NMR, ESR, NQR, Mössbauer, and mass spectrometry—to analyze molecular structures and dynamics. It covers principles, instrumentation, and applications of these methods.

Objectives of the course

- Understand the principles and applications of different molecular spectroscopy techniques.
- Learn the fundamentals of microwave, infrared, Raman, and electronic spectroscopy for molecular structure analysis.
- Gain knowledge of NMR spectroscopy, including chemical shift, spin-spin coupling, and advanced techniques.
- Explore the principles and applications of NQR, Mössbauer, and photoelectron spectroscopy for structural investigations.
- Study the fundamentals of ESR and mass spectrometry, including ionization techniques and fragmentation mechanisms.

Course Outline

Unit I: Molecular Spectroscopy I **(18 Hours)**

1.1 Fundamentals of Molecular Spectroscopy: Electromagnetic radiation - molecular energy types - absorption and emission spectra - signal-to-noise ratio, and factors affecting spectral transition width and intensity.

1.2 Microwave Spectroscopy: Rotational spectra of rigid and non-rigid diatomic and polyatomic molecules - isotopic substitution effects - Stark effect.

1.3 Infrared Spectroscopy: Vibrational energy of diatomic molecules (harmonic and anharmonic models), selection rules, diatomic vibrating rotator (P, Q, R branches), Oppenheimer approximation breakdown - polyatomic molecule spectra – overtones - Fermi resonance.

Unit II: Molecular Spectroscopy II (18 Hours)

2.1 Raman Spectroscopy: Quantum theory of Raman scattering - pure rotational, vibrational, and vibrational-rotational Raman spectra - selection rules - mutual exclusion principle - Laser Raman spectroscopy.

2.2 Electronic Spectroscopy: Electronic spectra of diatomic and polyatomic molecules - Born-Oppenheimer approximation - vibrational coarse structure - Franck-Condon principle, dissociation energy - rotational fine structure - Fortrat diagrams and predissociation.

2.3 Ultraviolet and Visible Spectroscopy: Principles of electronic absorption, chromophores and auxochromes - absorption laws - solvent effects - conjugation effects.

Unit III: NMR Spectroscopy (18 Hours)

3.1 Fundamentals of NMR Spectroscopy: Nuclear spin states, NMR-active nuclei, magnetic moment, Larmor equation, resonance, Boltzmann distribution, relaxation mechanisms (T1, T2), Bloch equations, and comparison of CW and FT.

3.2 Chemical Shift and Spin-Spin Coupling: Chemical shift principles (shielding, deshielding, influencing factors) - spin-spin coupling (origin, rules, J-coupling, Karplus equation), common spin systems (AX, AB, A_2, AMX, ABX), and signal simplification techniques (lanthanide shift reagents, NOE).

3.3 Advanced NMR Techniques: Principle of ^{13}C NMR, VT-NMR and MRI, decoupling techniques, APT and DEPT spectra (DEPT-45, DEPT-90, DEPT-135). NMR of other nuclei: ^{19}F NMR (precessional frequency, heteronuclear coupling) and ^{31}P NMR (chemical shifts, coupling).

UNIT IV: NQR and Photoelectron Spectroscopy (18 Hours)

4.1 Nuclear Quadrupole Resonance (NQR) Spectroscopy: Principles of nuclear quadrupole resonance (NQR) - quadrupolar nucleus - electric field gradient, energy levels - effects of magnetic fields on quadrupolar transitions.

4.2 Mössbauer Spectroscopy: Fundamental concepts, isomer shifts, magnetic interactions and Mössbauer emission spectroscopy techniques.

4.3 Photoelectron Spectroscopy (PES) and Auger Electron Spectroscopy (AES): Principles and techniques of X-ray Photoelectron Spectroscopy (XPS) and Ultraviolet Photoelectron Spectroscopy (UV-PES), ionization potential evaluation, ESCA, and fundamental concepts of AES for chemical analysis.

UNIT V: ESR and Mass Spectroscopy (18 Hours)

5.1 Electron Spin Resonance (ESR) Spectroscopy: Principles of ESR, electron spin interactions, hyperfine splitting, factors affecting g-value, ESR spectra of free radicals, anisotropic systems, and triplet states. Concepts of zero-field splitting and Kramers' degeneracy.

5.2 Mass Spectrometry (MS): Principles, resolution, ionization techniques (EI, CI, FAB). Molecular ion and fragmentation patterns, metastable ions, base and isotope peaks. Advanced fragmentation mechanisms, McLafferty rearrangement, and rules governing fragmentation.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Ed., Tata McGraw Hill, 1994.
2. G. Aruldhas, *Molecular Structure and Spectroscopy*, 2nd Ed., PHI Learning, 2007.
3. J. M. Hollas, *Modern Spectroscopy*, 4th Ed., John Wiley & Sons, 2004.
4. R. S. Drago, *Physical Methods in Chemistry*, W. B. Saunders, 1992.
5. P. Atkins and J. de Paula, *Physical Chemistry*, 9th Ed., Oxford University Press, 2010.

Reference Books:

1. D. A. Skoog, F. J. Holler, and T. A. Nieman, *Principles of Instrumental Analysis*, 6th Ed., Thomson, 2007.
2. W. Kemp, *Organic Spectroscopy*, 3rd Ed., Macmillan, 1991.
3. J. W. Robinson, *Atomic Spectroscopy*, 2nd Ed., CRC Press, 1996.
4. R. M. Silverstein, F. X. Webster, and D. J. Kiemle, *Spectrometric Identification of Organic Compounds*, 7th Ed., Wiley, 2005.

Website and e-learning source

1. MIT Open Course Ware - Spectroscopy: https://ocw.mit.edu/courses/chemistry/5-33-advanced-chemical-instrumentation-fall-2008/
2. NPTEL Online Courses - Molecular Spectroscopy: https://nptel.ac.in/courses/104103112
3. ChemLibreTexts - Spectroscopy: https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy
4. Khan Academy - NMR and Mass Spectrometry: https://www.khanacademy.org/science/organic-chemistry/spectroscopy-jay

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	Recall the fundamental principles of molecular spectroscopy and the different spectroscopic techniques.	**K1**
CO-2	Explain the mechanisms behind various spectroscopic transitions, including vibrational, rotational, and electronic spectra.	**K2**
CO-3	Utilize spectroscopic techniques such as NMR, ESR, and mass spectrometry for molecular identification and structural elucidation.	**K3**
CO-4	Interpret spectral data and differentiate between various spectroscopic methods for solving chemical problems.	**K4**
CO-5	Assess the advantages and limitations of different spectroscopic techniques in research and industrial applications.	**K5**
CO-6	Develop new analytical methodologies using spectroscopic tools for advanced chemical investigations.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
II	**P25CH10E**	**Spectrometric techniques**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %

Mapping Correlation	**Low**	**Medium**	**High**	**No Correlation**
Level of Correlation	**1**	**3**	**9**	**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K – Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Spectrometric Techniques course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Spectrometric Techniques course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	INORGANIC CHEMISTRY – III				P25CH11
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	III	Lecture	6	5

Course description

This course provides a comprehensive study of electronic, infrared, Raman, electron paramagnetic resonance, nuclear magnetic resonance, Mossbauer and nuclear quadrupole resonance spectral and magnetic techniques used to characterize metal complexes, covering fundamental principles, instrumentation, and applications for structural and electronic structure elucidation.

Objectives of the course

- To learn the theoretical aspects and applications of electronic spectroscopy and the structural elucidation of inorganic compounds by IR and Raman spectroscopy.
- To study the theory and application of magnetic properties.
- To apply the principles and applications of EPR spectroscopy for studying materials with unpaired electrons, including metal complexes.
- To identify NMR of different nuclei and apply to find the structure of coordination and organometallic complexes.
- To impart the knowledge of Mossbauer and NQR spectroscopy for selected compounds.

Course Outline

UNIT-I: Electronic, IR and Raman Spectroscopy (18 Hours)

Microstates, terms and energy levels for d^1 - d^9 ions in cubic and square fields - intensity of bands - group theoretical approach to selection rules - effect of distortion and spin - orbit coupling on spectra - Orgel and Tanabe-Sugano diagrams - Charge transfer spectra-electronic spectra of $[Ru(bpy)_3]^{2+}$ and $[Cu(phen)_3]^{2+}$ complexes. Effect of isotopic substitution on the vibrational spectra of molecules - combined uses of IR and Raman spectroscopy in the structural elucidation of simple molecules like N_2O, ClF_3, NO_3^-, ClO_4^- - uses of group vibrations in the structural elucidation of metal complexes of thiourea, thiocyanate, sulphate and dimethyl sulfoxide - Applications of IR and Raman spectroscopy to coordination and organometallic complexes - Resonance Raman Spectroscopy.

UNIT-II: Magnetic Characteristics (18 Hours)

Types of magnetism (Dia, para, ferro and antiferrro). Magnetic properties of Lanthanides and Actinides - Determination of Magnetic Susceptibility Methods (Gouy's, Faraday's, NMR, Magnetic Anisotropy, Null deflection method for Crystals) - Magnetic properties of free ions

- first order Zeeman effect - Second order Zeeman effect - states KT – states << KT- Magnetic moment, Electronic spectra and structures of Tetrahalocobalt(II) Ions, Isothiocyanatobis(*p-toluidine*)cobalt(II), Anomalous magnetic moments- equilibrium between two spin states-magnetically nonequivalent sites- solute-solvent, solute-solute interaction- temperature independent paramagnetism.- spin pairing and Spin crossover in coordination compounds.

UNIT-III: Electron Paramagnetic Resonance spectroscopy (18 Hours)

Theory of EPR spectroscopy - Hyperfine splitting in simple systems and various structures - spin densities and McConell relationship - factors affecting the magnitude of g and A tensors - Interactions affecting the energies of unpaired electrons - Zero-field splitting and Kramer's degeneracy - Anisotropy in the Hyperfine coupling constant - Nuclear Quadrupole interaction - Spin Hamiltonian - Line widths in solid state EPR - Electron delocalization - Study of Inorganic compounds (Mn(II) and Fe(II), complexes) - Effect of pH in Ti(III)EDTA Complexes - Analytical and Biological Applications.

UNIT-IV: NMR Spectroscopy (18 Hours)

Examples for different spin systems - chemical shift and coupling constants (spin-spin coupling) involving different nuclei (1H, 19F, 31P, 13C, 29Si, 119Sn, 183W) - interpretation and applications to inorganic compounds - 31P NMR spectrum of $[Cp^*Rh(curc)(PTA)][SO_3CF_3]$ - effect of quadrupolar nuclei (2H, 10B, 11B) on the 1H NMR spectra - effect of low abundance isotopes on NMR- satellite spectra. Systems with chemical exchange - study of fluxional behavior of molecules - an elementary treatment of second order spectra - spin tickling and spin decoupling – the nuclear overhauser effect and gated decoupling - NMR of paramagnetic molecules - chiral and prochiral non- equivalence coincidences - Lanthanide shift reagents.

UNIT-V: Mossbauer and NQR spectroscopy (18 Hours)

Mossbauer Spectroscopy: Isomer shift - Doppler effect - recoil energy magnetic interactions Mossbauer emission spectroscopy - application to ^{57}Fe, ^{119}Sn - Mossbauer spectrum of iron carbonyl compounds. Time and temperature-dependant effects.

NQR spectroscopy - characteristics of quadrupolar nucleus - effects of field gradient and magnetic field upon quadrupolar energy levels - NQR transitions - application to NQR spectroscopy.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Books for Study

1. E. Gillan and E. S. Stern, "Electronic Absorption spectroscopy of inorganic compounds", Wiley, New York.

2. N Banwell, Fundamentals of molecular spectroscopy, 3rd edn., 1983, TMH, New Delhi.
3. Nakamoto, "Infrared Spectra of Inorganic and coordination compounds, 2nd edn., 1970, Arnold, London.
4. H. Kaur, "Instrumental methods of Chemical Analysis", 2020, 13th edn., Pragati Prakashan, Meerut.
5. R. S. Drago, Physical Methods in Inorganic Chemistry, 3rd edn., 1965, Wiley Eastern company, London.

Books for Reference

1. F. A. Cotton and G. Wilkinson, "Advanced Inorganic Chemistry" 5th edn., 1990, Wiley-Interscience Publication, New York.
2. G.M. Barrow, "Introduction to Molecular Spectroscopy", 1962, McGraw Hill, New York.
3. J. D. Roberts, "High Resolution Nuclear Magnetic Resonance", McGraw- Hill, New York.
4. T. P. Das and E. L. Hahn, "Nuclear Quadrupole Resonance Spectroscopy", 1958, Academic Press, New York.

Website and e- Learning Sources

1. https://www.scribd.com/document/469201441/h-kaur-book-spectroscopy-pdf-download?yqcWM3lx3fNeM=HuU76GEG8bOYNZY
2. https://pdfcoffee.com/physical-methods-russell-s-drago-pdf-free.html
3. https://www.scribd.com/document/655524963/Spectroscopy-C-N-Banwell
4. https://batch.libretexts.org/print/Letter/Finished/chem-366631/Full.pdf

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	investigate the theoretical background and applications of electronic spectroscopy and examine the structure of inorganic molecules using IR and Raman spectroscopy.	**K1**
CO-2	understand the principles and uses of magnetic characteristics of metal complexes.	**K2**
CO-3	comprehend the principles of EPR, apply it to various metal complexes and interpret spectra.	**K3**
CO-4	reveal the structure of coordination and organometallic complexes by learning about the NMR of various nuclei.	**K4**
CO-5	convey knowledge of NQR and Mossbauer spectroscopy for certain inorganic compounds.	**K5**
CO-6	apply spectral and magnetic concepts, and relate them to the structure and bonding of metal complexes.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
III	**P25CH11**	**Inorganic chemistry - III**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**		**No Correlation**
Level of Correlation	**1**	**3**		**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Inorganic Chemistry - III course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Inorganic Chemistry - III course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	ORGANIC CHEMISTRY - III				P25CH12
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	III	Lecture	6	5

Course Description

The course outlines the concept of elimination reaction and their mechanism. It furnishes the detailed description of the principle in pericylic reactions and the concept of ORD and CD. It also overviews the various heterocyclic compounds and to explore the application in medicinal chemistry and industrial processes.

Objectives of the course

- To appreciate the concept of elimination reactions and their reaction mechanisms
- To understand the principle behind pericyclic reactions and the concept of ORD-CD
- To understand the classification, nomenclature, structure, reactivity, and synthesis of various heterocyclic compounds, and to explore their applications in medicinal chemistry and industrial processes.
- To equip students with the skills to effectively use, choose, and apply reagents in chemical reactions.
- To understand the classification of proteins and nucleic acids

Course Outline

UNIT-I: Elimination Reactions (18 Hours)

conditions for elimination, classification – alpha and beta eliminations and their mechanistic paths, Mechanism of E^1, E^2, E^1CB reactions, orientation of double bond – Hoffmann and Saytzeff rule, justification and deviation of Hofmann and Saytzeff rules.

Stereochemistry of double bond, syn and anti-elimination, experimental evidence in favor of anti-elimination, reactivity, effect of substrate structure, attacking bases, leaving group, and medium**.** Hoffmann degradation, dehydration of alcohols, dehydrohalogenation, Decomposition of quaternary ammonium compounds, formation of 1,2-dichloro acetylene, Pyrolytic elimination – Cope reaction, Chugaev reaction. Elimination involving substituents other than hydrogen, NGP in elimination, ion pairing, Competition between elimination and substitution reactions, Bredt's rule.

UNIT-II: Pericyclic Reactions and Optical Rotatory Dispersion and Circular Dichroism (18 Hours)

Characteristics - classification - molecular orbital symmetry - frontier orbitals ethylene,1,3-butadiene, 1,3,5-hexatriene, and allyl systems - applications of frontier molecular orbital

(FMO) and molecular orbital correlation diagram methods to electrocyclic reactions (4n and 4n+2) system and cycloaddition reactions (2+2 and 4+2n electron system) - Woodward Hofmann rules - sigmatropic rearrangement (1,3 and 1,5 hydrogen shift) cope and claisen rearrangement (3,3 carbon shift) - chelotropic reactions. Introduction to theory and terminology - circular birefringence – circular dichroism - cotton effect and ORD curves - comparison between ORD and CD and their inter-relationship - axial halo ketone rule and octant rule - applications to determine the absolute configuration of monocyclic ketones and steroids.

UNIT-III: Heterocyclic (18 Hours)

3.1. Systematic nomenclature for monocyclic fused and bridged heterocyclic compounds.

3.2. Synthesis and reactions of five and six membered ring systems: Benzo pyrroles, Benzofurans, Benzo thiophene, pyrimidines, azoarenes, oxiranes, oxetanes, thietanes (3 & 4 membered heterocyclic). Heterocyclic systems containing Phosphorus- synthesis and reactions of phosphoranes, phospholanes. Tautomerism in aromatic heterocyclics, the biological importance of heterocyclics.

UNIT-IV: Reagents for Oxidation and Reduction Reaction (18 Hours)

4.1. Oxidation reactions: CrO_3, PDC, PCC, $KMnO_4$, MnO_2, SeO_2, $Pb(OAc)_4$ Swern, OsO_4, m-CPBA, O_3.

4.2. Reduction reactions: Catalytic Hydrogenation, LAH, $NaBH_4$, $LiAlH(OBu)_3$, $NaCNBH_3$, Bu_3SnH, LDA, Me_2CuLi, MPV, H_2/Pd-C,$[(C_6H_5)_3P]_3RhCl$, NH_2NH_2, DIBAL-H.

UNIT-V: Proteins, Nucleic Acids (18 Hours)

Proteins classification, 2^o, 3^o, and quaternary structure of proteins, Chemistry of oxytocin, denaturation of proteins, biosynthesis of protein. Nucleotides and Nucleosides - DNA function and composition of nucleic acids, structure of DNA-Watson-Crick (WC-model), different forms of DNA, Chargaff's rule of DNA composition. Denaturation, and renaturation of DNA strands. Tm of DNA and its significance. 1^o, and 2^o structure.

Structure and function of different types of RNA (m-RNA, t-RNA, and rRNA) genes - genetic code and information storage, Replication of DNA, DNA damages, mutation, and repair-determination of the base sequence of DNA, DNA fingerprinting - polymerase chain reactions and RT-PCR.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. Jerry March, "Advanced Organic Chemistry (Reactions, Mechanisms and Structure)", - Wiley, 2005.

2. Thomas H. Lowry and K. S. Richardson, "Mechanism and Theory in Organic Chemistry" Addisson-Wesley, 1988.
3. V. K. Ahluwalia and R. K. Parashar, "Organic Reaction Mechanism", Narosa, 2006.
4. Raj K. Bansal, "Heterocyclic Chemistry (Synthesis, Reactions, and Mechanism)", Wiley- Eastern Limited 1999.
5. J. H. Weil, "General Bio-chemistry" - New Age International, 1997.
6. I. L. Finar, "Organic Chemistry", Volume-II, 5th Ed., (2006).

Book for Reference:

1. Structure and Mechanisms, F. Carey, R. Sundberg, "Advanced Organic Chemistry.Part-A". 4th Ed., Kluwer Publishers, 2000.
2. Michael B. Smith, J. March, "March's Advanced Organic Chemistry", John Wiley & Sons, 6th Ed., 2007.
3. J. Clayden, N. Greeves, P. Wothers, "Organic Chemistry", Oxford University Press, 2001.
4. J. Mc. Murry, "Organic Chemistry", Brooks/Cole publisher, 5th Ed., 2000.
5. M. B. Smith, 'Organic Synthesis', Academic Press, Elsevier, 3rd Ed., 2010.

Websites and e-Learning Source:

1. https://www.chemistryconnected.com/
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. https://organicers.org/

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire conditions for elimination, classification of eliminations, E^1, E^2, E^1CB reactions, Characteristics and classification, molecular orbital symmetry, frontier orbitals.	**K1**
CO-2	understand Woodward Hoffmann rules, sigmatropic rearrangement, chelotropic reactions, ring structure, reactivity, and synthesis of heterocyclic compounds.	**K2**
CO-3	apply the use of reagents in practical synthesis, replication, mutation, and repair mechanisms of DNA	**K3**
CO-4	analyze competition between elimination and substitution reactions, ion pairing. effectiveness of different reagents under various conditions.	**K4**
CO-5	evaluate importance of heterocyclics in medicinal chemistry, determining base sequences of DNA, assessing protein structure and function.	**K5**
CO-6	Creating new elimination reactions, considering substituents other than hydrogen, new interpretations of circular birefringence and dichroism phenomena.	**K6**

Semester	Course code	Title of the Course			Hours	Credits
III	P25CH12	Organic Chemistry – III			6	5
(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Organic Chemistry-III course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Organic Chemistry-III course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	PHYSICAL CHEMISTRY - II				P25CH13
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	III	Lecture	6	5

Course Description

This course provides an in-depth exploration of advanced concepts in chemical thermodynamics, statistical thermodynamics, irreversible thermodynamics, and group theory. The course is designed for students with a strong foundation in physical chemistry and aims to equip them with theoretical and practical knowledge of thermodynamic principles, phase equilibria, statistical mechanics, transport processes, and symmetry applications in spectroscopy and molecular orbital theory.

Objectives of the course

- Understand the application of chemical thermodynamics in determining thermodynamic properties, phase equilibria, and real gas behavior.
- Learn the fundamentals of statistical thermodynamics, including phase space, ensembles, partition functions, and quantum statistics.
- Explore the principles of irreversible thermodynamics, Onsager relations, and entropy production in non-equilibrium processes.
- Develop knowledge of group theory, symmetry elements, character tables, and their applications in chemistry.
- Apply group theory to spectroscopy, molecular orbital theory, and vibrational analysis of molecules

Course Outline

Unit-I: Application of Chemical Thermodynamics and Phase Equilibria (18 Hours)

1.1 Application of Chemical Thermodynamics: Partial molar properties - partial molar free energy – Gibbs – Duhem equation – determination of chemical potential (Direct method and method of intercept) - thermodynamic properties of real gases - fugacity concept- Calculation fugacity of real gas – concept of activity and activity co-efficient – experimental determination of activity and activity co-efficient.

1.2: Chemical and Phase Equilibria: Third law of thermodynamics – Absolute entropies – Determination of absolute entropies – Exception to third law – Gibbs phase rule – 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.

Unit-II: Statistical Thermodynamics (18 Hours)

2.1 Fundamentals of Statistical Thermodynamics: Need for statistical thermodynamics - definition of state of a system – phase space - ensembles - Thermodynamic probability – Boltzmann distribution law and its derivation - Boltzmann-Planck equation- Partition functions (translational, rotational and vibrational) - thermodynamic properties from partition functions- partition function and equilibrium constant.

2.2 Quantum Statistics and Heat Capacities: Fermi-Dirac and Bose-Einstein statistics- Comparison of Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistics - photon gas and electron gas according to such statistics - Einstein's and Debye's theories of heat capacities of solids.

UNIT-III: Irreversible Thermodynamics (18 Hours)

3.1 Principles of Irreversible Thermodynamics: Local equilibrium theory of thermodynamics – Postulate of local equilibrium - Principal aims of classical irreversible thermodynamics – Transport equations – Fourier's law, Fick's law and Ohm's law – Entropy flow and entropy production in irreversible processes.

3.2 Onsager Relations and Applications: linear flux-force relations. Phenomenological laws and Linear laws – Onsager's reciprocity relations, applications to electrokinetic phenomena, Coupled phenomena - Peltier and Seeback effects, Curie's theorem – Prigogine's principles of minimum entropy production. Derivations and calculation of changes in entropy as phase changes.

Unit-IV: Group theory (18 Hours)

4.1 Fundamentals of Group Theory: Molecular symmetry elements and symmetry operations – Group postulates and types of groups- point groups – assignment of point groups to molecules – order of a group, sub groups, similarity transformations – conjugate elements and classes- Group multiplication table-cyclic and inverse rule.

4.2 Matrix Representation and Character Tables:

Matrix representation of symmetry operations, character of the matrix – reducible and irreducible representation - properties of irreducible representation – Mulliken notations - statement and proof of Great orthogonality theorem and its consequences - construction of character tables – C_2v, C_3v, C_4v and D_3h point groups – Determinations of symmetry species for translation and rotations – Direct product concept – Symmetry of hybrid orbitals.

Unit-V: Applications of Group theory (18 Hours)

5.1 Spectroscopy and Selection Rules: Standard reduction formula relating reducible and irreducible representations – symmetries of normal modes of vibrations in linear and non-linear molecules – Selection rules for vibrational spectra – IR and Raman active mutual

exclusion principle with illustrations - symmetries of molecular orbitals and symmetry selection rule for electronic transition in ethylene formaldehyde and benzene.

5.2 Molecular Orbital and Vibrational Applications: Applications of group theory for the determination of hybridization of atomic orbitals of nonlinear AX_2 (H_2O), AX_3 (NH_3 and BF_3) and AX_4 (CH_4 and XeF_4) molecules and linear molecules (CO_2) - Determination of symmetries of vibrational modes in non-linear (H_2O) and linear molecules (CO_2) - Application of Group Theory in Vibrational Spectroscopy.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. P. W. Atkins and J. de Paula, *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
2. I. N. Levine, *Physical Chemistry*, 6th Ed., McGraw Hill, 2009.
3. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Ed., Wiley, 2003.
4. D. A. McQuarrie and J. D. Simon, *Molecular Thermodynamics*, University Science Books, 1999.
5. R. Stephen Berry, Stuart A. Rice, and John Ross, *Physical Chemistry*, 2nd Ed., Oxford University Press, 2000.

Book for Reference:

1. R. P. Rastogi and R. R. Mishra, *an Introduction to Chemical Thermodynamics*, Vikas Publishing House, 2009.
2. J. Rajaram and J. C. Kuriacose, *Thermodynamics for Chemists*, S. Chand & Co., 1996.
3. V. Ramakrishnan and M. S. Gopinathan, *Group Theory in Chemistry*, Vishal Publishing, 2017.
4. D. A. McQuarrie, *Statistical Mechanics*, University Science Books, 2000.

Websites and e-Learning Source:

1. MIT Open Course Ware - Thermodynamics & Statistical Mechanics: https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/
2. NPTEL Online Courses - Statistical Thermodynamics & Group Theory: https://nptel.ac.in/courses/104103063
3. ChemLibreTexts - Thermodynamics & Group Theory: https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps
4. Khan Academy - Thermodynamics: https://www.khanacademy.org/science/chemistry/thermodynamics-chemistry

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	Recall fundamental concepts of thermodynamics, statistical mechanics, irreversible processes, and group theory.	**K1**
CO-2	Explain thermodynamic principles governing chemical equilibria, phase transitions, molecular symmetry, and quantum statistics.	**K2**
CO-3	Utilize partition functions, Onsager's relations, and group theory concepts for solving problems in chemical and spectroscopic applications.	**K3**
CO-4	Interpret thermodynamic models, entropy production, and analyze molecular symmetry elements in different chemical systems.	**K4**
CO-5	Assess the role of symmetry in spectroscopy, hybridization, and vibrational analysis of molecules.	**K5**
CO-6	Develop new thermodynamic models and apply group theory for predicting molecular properties and spectroscopic transitions.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
III	**P25CH13**	**Physical Chemistry - II**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Physical Chemistry - II course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Physical Chemistry - II course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	ORGANIC CHEMISTRY PRACTICAL				P25CH14P
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	III	Practical	6	5

Course Description

This course aims to equip students with essential skills in organic chemistry, including separation, qualitative analysis, and synthesis of organic compounds. Students will develop proficiency in handling chemical reagents for separating binary organic mixtures, systematically analyzing separated components, and preparing derivatives. The curriculum emphasizes constructing appropriate experimental setups for single and double-stage organic preparations, as well as experimenting with various purification and drying techniques to process compounds effectively.

Objectives of the course

- To understand the concept of separation, qualitative analysis, and preparation of organic compounds.
- To develop analytical skills in the handling of chemical reagents for separation of binary organic mixtures.
- To analyze the separated organic components systematically and derivative them suitably.
- To construct a suitable experimental setup for the organic preparations involving single and double stages.
- To experiment with different purification and drying techniques for the compound processing.

Course Outline

Separation and analysis:

Qualitative analysis of an organic mixture containing two components

Pilot separation, analysis, and derivatization. The mixture contains all functional groups including halogens (nuclear, side chain).

Preparation of organic compounds (Single Stage)

(a) Resacetophenonone from resorcinol (acetylation)
(b) Phenyl-azo-2-naphthol from aniline (diazotization)
(c) Dibenzalacetone from benzaldehyde
(d) Methyl-m-nitrobenzene from methyl benzoate (nitration)
(e) Glucose penta acetate from glucose (acetylation)

(f) 2-Naphthylmethylether from 2-Naphthol (methylation)

Preparation of organic compounds (Double Stage)

(a) p-bromo acetanilide from aniline (acetylation and bromination).

(b) p-nitroaniline from acetanilide (nitrogen and hydrolysis).

(c) benzanilide from benzophenone (rearrangement)

(d) benzilic acid from benzoin (rearrangement)

(e) 1, 2, 4-triacetoxy benzene from hydroquinone (oxidation and acylation)

(f) acetyl salicylic acid from methyl salicylate (hydrolysis and acetylation)

(g) 1,3,5-tribromobenzene from aniline (bromination, diazotization, and hydrolysation)

(h) p-bromoaniline from acetanilide (bromination and hydrolysis).

(i) m-nitroaniline from nitrobenzene.

Estimations:

Quantitative analysis of organic compounds

(a) Estimation of phenol/aniline (bromination)

(b) Estimation of glucose (redox)

(c) Estimation of Ethyl methyl ketone (iodimetry)

(d)Estimation of Ascorbic acid (iodimetry)

(e) Estimation of Aromatic nitro groups (reduction)

(f) Estimation of Glycine (acidimetry)

(g) Estimation of Formalin (iodimetry)

(h) Estimation of Acetyl group in ester (alkalimetry)

(i) Estimation of Hydroxyl group (acetylation)

(j) Estimation of Amino group (acetylation)

Books for Study:

1. Dey and Sitaraman, "Laboratory Manual of Organic Chemistry", Allied Publishers, 1992.
2. N. S. Gnanaprakasam, G. Ramamurthy, "Organic Chemistry Lab Manual", S. Viswanathan Printers and Publishers Pvt. Ltd., 2015.

Books for Reference:

1. Furniss, S. B.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R. "Vogel's Text Book of Practical Organic Chemistry", 5th Ed., Longman Scientific & Technical, England, 1989.

Course Learning Outcomes:

1. Students learn the separation of binary organic mixtures
2. Students understand the green chemistry concepts
3. Students learn the skills of doing micro-level analysis

4. Students get to know the methods of qualitative analysis of organic compounds
5. Students understand the single-stage preparation of organic compounds
6. Students learn about the derivative of the organic functional groups
7. Students understand the quantitative analysis in organic chemistry
8. Students know the estimation of organic compounds.
9. Students understand the double-stage organic preparations.
10. Students get to know the chromatographic techniques.

Semester	Course code	Title of the Course			Hours	Credits
III	P25CH14P	Organic Chemistry Practical			6	5
(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K – Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1								
K2								
K3								
K4								
K5								
K6								
Non-Scholastic								
Total	5	6	4	5	20	5	25	100%

The COs and POs for the Organic Chemistry Practical course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Organic Chemistry Practical course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	SOLID STATE CHEMISTRY				P25CH15E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	II	III	Lecture	6	3

Course description

This course deals with crystal structure and crystal engineering of organic solids, metallo-organic frame works and preparative methods in solid state chemistry, design of nanoporous solids and magnetic materials. It will also help to understand the chemistry of solids, covering crystal structures, bonding, synthesis, and properties, with emphasis on the relationship between structure and functionality in materials like pharmaceutical phases, NLO and OLED materials, lasers, phosphors and superconductors.

Objectives of the course

- To understand and manipulate the structure of organic solids, ultimately enabling them to design and control the properties of crystalline materials.
- To provide understanding of fundamental chemistry, synthesis, characterization, and diverse applications of metal-organic frame work.
- To equip with the facts and skills to understand and apply various preparative methods in solid-state chemistry.
- To give knowledge on magnetic materials and optical properties and analyze, predict, and manipulate these properties for various applications.
- To know the structure, properties, synthesis, and applications of organic solids.

Course Outline

UNIT-I: (18 Hours)

Crystal Structure and Crystal Engineering of Organic Solids Types of close packing – hcp and ccp – packing efficiency – SC, BCC, and FCC, radius ratio rule – applications – polyhedral description of solids – structure types: Na_2O, Cs_2O, rutile, perovskite (ABO_3), ReO_3, K_2NiF_4, spinels and antispinels. Hydrogen bonded supramolecular patterns involving water / carboxyl / halide motifs – concepts of different types of synthons based on noncovalent interactions – principles of crystal engineering and noncovalent synthesis – polymorphism and pseudo polymorphism – supramolecular isomorphism, polymorphism and crystal engineering of pharmaceutical phases.

UNIT-II: (18 Hours)

Metallo Organic Frameworks MOFs (Metallo Organic Frameworks) – organometallic systems – combinations of different interactions to design molecular rods, triangles, ladders,

networks, etc. Design of nanoporous solids. Inter ligand hydrogen bonds in metal complexes – implications for drug design – crystal engineering of NLO and OLED materials.

UNIT-III: (18 Hours)

Preparative Methods in Solid State Chemistry Experimental procedure, co-precipitation as a precursor to solid state reaction, other precursor methods, kinetics of solid state reactions – crystallizations of solutions, melts, glasses and gels, solutions and gels: zeolite synthesis – precipitation from solution or melt: flux method, epitaxial growth of thin layers, verneuil flame fusion method. Graphite intercalation compounds, transition metal dichalcogenide and other intercalation compounds, ion exchange reaction, synthesis of new metastable phases by 'Chimie Douce'. Electrochemical reduction methods – preparation of thin films, chemical and electrochemical methods, physical methods – growth of single crystals, Czochralski method, BridgmanStockbarger methods – zone melting. Vapour phase transport, hydrothermal methods, comparison of different methods – high pressure and hydrothermal methods and dry high pressure methods.

UNIT-IV: (18 Hours)

Magnetic Materials and Optical Properties Selected examples of magnetic materials and their properties – metals and alloys, transition metal oxides, spinels, garnets, ilmenite and perovskites. Magneto plumbites – applications – structure/property relations – transformer, information storage, magnetic bubble memory devices, permanent magnets. Luminescence, Lasers and phosphors – definitions and general comments, configurational coordinate model, some phosphor materials, antiStokes phosphors – lasers – the ruby laser, Neodymium lasers

UNIT-V: (18 Hours)

Organic Solid-State Chemistry Topochemical control of solid-state organic reactions – intramolecular reactions – conformational effects – intermolecular reactions – molecular packing effects – photodimerization of 2ethoxycinnamic acid (α form, β form, γ form) – photopolymerization of 2,5 distyrylpyrazine – photopolymerizations of diacetylenes. Asymmetric syntheses – dimerization of anthracene – control of molecular packing arrangements. Organic reactions within inorganic host structures – electrically conductive organic solids – organic metals, conjugated systems, doped polyacetylene, polyparaphenylene, polypyrrole – organic charge transfer complexes – new superconductors.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Books for Study

1. R. West, Solid State Chemistry and Its Applications; 2nd Ed., John Wiley and sons, New York, 2014.

2. J. M. Lehn, Supramolecular Chemistry; VCH, Weinheim, 1995.
3. G. R. Desiraju, Crystal Engineering: The Design of Organic Solids; Elsevier, Amsterdam, 1989.
4. G. R. Desiraju, and T. Steiner, The Weak Hydrogen Bond in Structural Chemistry and Biology; Oxford University Press: Oxford, 2002.

Books for Reference

1. G. A. Jeffrey, Introduction to Hydrogen Bonding; Oxford University Press, New York, 1997.
2. J. M. Lehn, Transition Metals in Supramolecular Chemistry; Vol 5, John Wiley and Sons, New York, 1999.
3. C. N. R. Rao, Current Science, 2001, 81, 1030.

Website and e- Learning Sources

1. Crystal Growth and Design.http://www.pubs.acs.org/journals/cgdefu/index.html
2. Crystal Engineering Communication, http://www.rsc.org /Publishing/ Journals /ce/ index.asp

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	predict and design organic crystal structures, and relate structure to properties, ultimately enabling them to manipulate solid-state properties for various applications.	**K1**
CO-2	equip with knowledge of metal-organic frame work fundamentals, synthesis, characterization, and applications.	**K2**
CO-3	synthesize and characterize solid-state materials, understand different synthesis techniques, and apply their knowledge to solve real-world problems.	**K3**
CO-4	understand the fundamental concepts, predict material behavior, and apply to various engineering applications, including device design and material selection.	**K4**
CO-5	appreciate the unique properties of organic solids, including their structure, bonding, and interactions and predict their behavior in various applications.	**K5**
CO-6	know the fundamental concepts of solid materials, including their structure, bonding, synthesis, and properties, and apply to predict and explain material behavior.	**K6**

Semester	Course code	Title of the Course			Hours	Credits
III	P25CH15E	Solid State Chemistry			6	3
(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Solid State Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Solid State Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	MEDICINAL CHEMISTRY				P25CH15E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	II	III	Lecture	6	3

Course Description

Medicinal chemistry enables the students to find the chemistry behind the development of pharmaceutical materials. It also provides the detailed knowledge of mechanism and action drugs. The course familiarizes the students to understand the mode of action of diabetic agents, the treatment and the knowledge with the applications of various antibiotics.

Objectives of the course

- To study the chemistry behind the development of pharmaceutical materials.
- To gain knowledge on the mechanism and action of drugs.
- To understand the need for antibiotics and the usage of drugs.
- To familiarize oneself with the mode of action of diabetic agents and the treatment of diabetes.
- To identify and apply the action of various antibiotics.

Course Outline

UNIT-I: Introduction to receptors **(18 Hours)**

Introduction, targets, Agonist, antagonist, partial agonist. Receptors, Receptor types, Theories of Drug- receptor interaction, Drug synergism, Drug resistance, and physicochemical factors influencing drug action.

UNIT-II: **(18 Hours)**

Antibiotics: Introduction, Targets of antibiotics action, classification of antibiotics, enzyme-based mechanism of action, SAR of penicillin's and tetracyclines, clinical application of penicillin's, cephalosporin. Current trends in antibiotic therapy.

UNIT-III: Antihypertensive agents and diuretics **(18 Hours)**

Classification of cardiovascular agents, introduction to hypertension, etiology, types, classification of antihypertensive agents, classification and mechanism of action of diuretics, Furosemide, Hydrochlorothiazide, Amiloride.

UNIT-IV: Antiviral and Antibacterial **(18 Hours)**

Classification of antiviral agents, Mechanism of action - Chloroquine Phosphate, Amodiaquine hydrochloride, and Pyrimethamine. Antibacterial: Classification and mechanism of action Sulphanilamide, Sulphapyridine, Sulphadiazine and Sulphisoxazole.

UNIT-V: Analgesics, Antipyretics, and Anti-inflammatory Drugs (18 Hours)

Introduction, Mechanism of inflammation, classification, and mechanism of action and paracetamol, Ibuprofen, Diclofenac, naproxen, indomethacin, phenylbutazone, and meperidine. Medicinal Chemistry of Antidiabetic Agents Introduction, Types of diabetics, Drugs used for the treatment, chemical classification, Mechanism of action, Treatment of diabetic mellitus. Chemistry of insulin, sulfonylurea.

Teaching Methodology: Lectures, Demonstration, Presentations and videos

Book for Study:

1. Wilson and Gisvold's textbook of organic medicinal and pharmaceutical chemistry,
2. Wilson, Charles Owens: Beale, John Marlowe; Block, John H, Lippincott William, 12th edition, 2011.
3. Graham L. Patrick, An Introduction to Medicinal Chemistry, 5th edition, Oxford University
4. Press, 2013. Jayashree Ghosh, A textbook of Pharmaceutical Chemistry, S. Chand and Co. Ltd, 1999,1999 ed.
5. O. LeRoy, Natural and synthetic organic medicinal compounds, Ealemi, 1976.
6. S. Ashutosh Kar, Medicinal Chemistry, Wiley Eastern Limited, New Delhi, 1993, New ed.

Book for Reference:

1. Foye's Principles of Medicinal Chemistry, Lippincott Williams, Seventh Edition, 2012
2. Burger's Medicinal Chemistry, Drug Discovery, and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic Press, 2010.
3. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, John M. Beale Jr and John M. Block, Wolters Kluwer, 2011, 12th ed.
4. P. Parimoo, A Textbook of Medical Chemistry, New Delhi: CBS Publishers.1995.
5. S. Ramakrishnan, K. G. Prasannan and R. Rajan, Textbook of Medical Biochemistry, Hyderabad: Orient Longman. 3rd edition, 2001.

Website and e-learning source

1. https://www.ncbi.nlm.nih.gov/books/NBK482447/
2. https://training.seer.cancer.gov/treatment/chemotherapy/types.html
3. https://www.classcentral.com/course/swayam-medicinal-chemistry12908

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire a comprehensive understanding of receptor targets, agonists, antagonists, and partial agonists, knowledge of the targets of antibiotic action and the classification of antibiotics.	**K1**
CO-2	understand various receptor types and the theories of drug-receptor interactions, the enzyme-based mechanisms of action for penicillins and tetracyclines, and the various types and classifications of antihypertensive agents and diuretics.	**K2**
CO-3	apply knowledge to explain drug synergism and drug resistance, to discuss the clinical applications of penicillins and cephalosporins, to explain the mechanisms of action of drugs like Furosemide, Hydrochlorothiazide, and Amiloride.	**K3**
CO-4	analyze the physicochemical factors influencing drug action, as well as the effectiveness and side effects of different antihypertensive agents and diuretics.	**K4**
CO-5	evaluate different drug interactions and their implications in medicinal chemistry, current trends in antibiotic therapy to make informed decisions in clinical practice, and the role of these agents in treating viral and bacterial infections.	**K5**
CO-6	create insights into the classification, mechanisms, and therapeutic applications of antiviral and antibacterial agents.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
III	**P25CH15E**	**Medicinal Chemistry**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K – Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	5	6	4	5	20	5	25	100%

The COs and POs for the Medicinal Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Medicinal Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	SMART MATERIALS IN EMERGING TECHNOLOGY				P25CH15E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	II	III	Lecture	6	3

Course Description

This course covers fundamental and advanced material chemistry, including metals, alloys, ceramics, polymers, and nanomaterials, with applications in electronics, optoelectronics, and energy storage. Students gain expertise in material selection, processing, and industrial applications, preparing them for careers in materials science and nanotechnology.

Objectives of the course

- To introduce fundamental concepts of material chemistry, including material classifications, structures, and phase diagrams.
- To understand the mechanical, thermal, and electrical properties of materials and their impact on performance and applications.
- To explore the structure, properties, and applications of ceramics, composites, and polymers, including biodegradable materials.
- To study advanced materials such as superconductors, nanomaterials, and conducting polymers for modern technological applications.
- To examine the role of organic materials in electronics and optoelectronics, including solar cells and energy storage systems.

Course Outline

Unit-I: Metals and Alloys (18 Hours)

Introduction to material chemistry past, present and future –Material Classifications – Metals, semiconductors and insulators –crystalline, Amorphous, Microcrystalline and nano - crystalline materials –Solid solutions, phase rule, binary phase diagrams, iron-iorn carbide phase diagram, intermetallic compounds, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstructure, properties and applications of ferrous and non –ferrous alloys.

Unit-II: Properties of Materials (18 Hours)

Mechanical Properties –Stress –strain diagrams of metallic, ceramic and polymeric materials, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture. Thermal Properties-Heat capacity, thermal conductivity, thermal expansion of materials –Electrical Properties –electrical conductivity effect of temperature on conductivity intrinsic and extrinsic semiconductors, dielectric properties. Imperfections in crystalline solids and their role in influencing various properties. Influence of microstructure

on material properties –Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals – corrosion and oxidation of materials.

Unit-III: Ceramics, Composites and Polymers (18 Hours)

Ceramics–classification –natural ceramics, silicates, oxides, non –oxide ceramics and glass ceramics, structure, properties and applications. Composites – Fabrication of metal matrix, polymer matrix and ceramic matrix composites – applications –carbon nano-composites Polymer –Biopolymers –Properties and Applications –Biodegradation of plastics.

Unit-IV: Advanced Materials (18 Hours)

High performing materials for device applications –liquid crystal displays, solar cells, light emitting diode, batteries, supercapacitors and fuel cells – Magnetic materials –High Tc superconductors –organic –inorganic hybrid nanomaterials -conducting polymers and their applications

Unit-V: Organic Materials for Electronic and Optoelectronics (18 Hours)

Small organic molecules in solar cells –chiral molecules and polymers in non-linear optics-molecular machines –organic electrode materials for electrochemical energy storage.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. Materials Science and Engineering by Raghavan V, Prentice Hall India Learning Private Limited; 5 editions (2004)
2. Materials science and engineering, An Introduction; by William D. Callister, Jr. John Wiley & Sons (2007)

Book for References:

1. Materials science and engineering, G.S. Upadhyaya and Anish Upadhyaya, VIVA Books Private Ltd., (2006)
2. Materials science, O.P. Khanna, IshKapur publications, (2003)

Website and e-learning source

1. https://onlinecourses.nptel.ac.in/noc24_mm42/preview?utm_
2. https://www.coursera.org/specializations/materials-science-for-technological-application?utm
3. https://ioe.iitm.ac.in/program/advanced-materials-and-nano-technology/?utm

Course Outcome		
CO. No.	CO-Statement On successful completion of this course, students will be able to	**Cognitive Level (K-Level)**
CO-1	Recall the fundamental concepts of material chemistry, including classifications, structures, and phase diagrams.	**K1**
CO-2	Explain the mechanical, thermal, electrical, and dielectric properties of materials and their role in material performance.	**K2**
CO-3	Apply the principles of material chemistry to understand the structure, properties, and fabrication of ceramics, composites, and polymers.	**K3**
CO-4	Analyze advanced materials such as superconductors, nanomaterials, and conducting polymers for their applications in energy storage and devices.	**K4**
CO-5	Evaluate and apply organic materials in electronic and optoelectronic applications, including solar cells and molecular machines.	**K5**
CO-6	Design and develop materials with tailored properties for specific applications in energy storage, corrosion protection, and environmental sustainability.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
III	**P25CH15E**	**Smart Materials in Emerging Technology**			**6**	**3**
CO'S	**Programme Outcome (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	6	3	3	0
CO2	9	9	6	6	3	0
CO3	9	9	6	6	3	3
CO4	9	9	9	6	3	3
CO5	9	9	9	9	6	3
CO6	9	9	6	6	3	3
Weightage	54	54	42	39	27	12
Weighted % of Course Contribution to POs	100 %	100 %	77 %	65 %	45 %	20 %
Mapping Correlation	**Low**		**Medium**	**High**		**No correlation**
Level of Correlation	**1**		**3**	**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K - Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO1/K1	PO1, PO2,PO3, PO4	PO5, PO6	-	-
CO2/K2	PO1, PO3, PO4	PO2, PO5	PO6	-
CO3/K3	PO1, PO2,PO3,	PO4, PO5	PO6	-
CO4/K4	PO1, PO2, PO5	PO4, PO6	PO3	-
CO5/K5	PO1	PO2, PO3, PO4, PO5	PO6	-
CO6/K6	PO1, PO2	PO3, PO4, PO5	PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1	1	4	3	7	12 %
K2	1	1	1	1	4	4	8	16 %
K3	1	2	1	1	5	5	10	20 %
K4	1	1	1	1	4	2	6	12 %
K5	1	1	1	1	4	2	6	12 %
K6	1	1	1	1	4	2	6	08 %
Non Scholastic	-	-	-	-	-	5	5	20 %
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Smart Materials in Emerging Technology course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Smart Materials in Emerging Technology course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	INORGANIC CHEMISTRY - IV				P25CH16
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	IV	Lecture	6	5

Course description

This course proposes whole learning of inorganic photochemistry, supramolecular chemistry, metals in medicine and metal drug discovery and design. Inorganic photochemistry focus on how light interacts with inorganic compounds, leading to chemical reactions. Supramolecular chemistry introduces non-covalent interactions and their role in forming complex and functional assemblies. Metals in medicine explain the crucial role of metals and their compounds in medical imaging, diagnosis, and treatment. Metal drug discovery and design focuses on the principles and practices of identifying and designing metal-based drugs.

Objectives of the course

- To provide the principles, mechanisms, and applications of photochemical reactions in inorganic systems.
- To recognize the catalysis and mechanism of photochemical reactions on solid surface.
- To acquire the knowledge in supramolecular chemistry of inorganic compounds.
- To focus the diverse roles of metals in medical imaging, drug development and impact on human health.
- To furnish metal-based drug discovery and design and enable them to contribute to the development of novel metallodrugs.

Course Outline

UNIT I: Inorganic Photochemistry (18 Hours)

Electronic transitions in metal complexes - metal centered and charge transfer transitions - various photo physical and photochemical processes of coordination compounds - uni molecular charge-transfer photochemistry of cobalt (III) complexes - mechanism of CTTM photo reduction. Ligand field photochemistry of Cr (III) complexes - Adamson's rule - conventional flash photolysis and single photon counting- photophysics and photochemistry of Ru -polypyridine complexes - emission and redox properties - photochemistry of organometallic compounds - metal-carbonyl compounds – compounds with metal - metal bonding - Reinecke's salt - chemical actinometer. Solar energy harvesting.

Unit II: Photochemical Reactions on Solid Surface (18 Hours)

Introduction, photo electron transfer mechanism, energy level diagram of solid acceptor and donor levels, Examples of photo catalytic metal/mixed metal oxides and their applications, semiconductor supported metal oxides for photolysis of water, Decomposition of organic pollutants, experimental setup, end product of organic products, carbon dioxide reduction, solar energy conversion and its storage. Chemiluminescence's in coordination complexes, Thexi state and Franck condon state.

UNIT III: Supramolecular Chemistry (18 Hours)

Concepts and languages of supramolecular chemistry - hydrogen bonds - C-H…X interactions - halogen bonds - π - π interactions - non-bonded interactions. M.O.F. (Metallo Organic Frameworks) - organometallic systems - combination of different interactions to design molecular rods, triangles ladders, networks etc - design of nanoporous solids - supramolecular metallo catalysis - organometallic receptors - co- catalysts - catalysis of synthetic reactions - biomolecular and abiotic catalysts - role of supramolecular chemistry in the development of nanoscience and technology - supramolecular devices - supramolecular photochemistry.

UNIT IV: Metals in Medicine (18 Hours)

Introduction: Inorganic Medicinal Chemistry - Metal Toxicity and Homeostasis - Vanadium-Based Diabetes Drugs - Platinum-Containing Anticancer Agents. Diagnostic Agents: Technetium Imaging Agents - Gadolinium MRI Imaging Agents. Metal Transport and Metallochaperones: Atx1 - Hah1 or Atox1.

UNIT V: Metal Drug, Discovery and Design (18 Hours)

Drug discovery and design - Therapeutic index and chemotherapeutic index - Structure activity relationship - Factors governing drug design - Computer aided drug design - Gold-based drugs -treatment of cancer and rheumatoid - mechanism of interaction. Lithium containing drugs- uses - mode of interaction - side effects. Silver based drugs anti-bacterial - antifungal agent - anticancer agent. Bismuth containing drugs - the treatment of acidity and related diseases.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. J. Ferraudi, "Elements of Inorganic Photochemistry", 1988, Wiley, New York. (Unit: I and II)
2. Adamson, A.W and Fleischauer, P.D (1975): Concepts of Inorganic Photochemistry, Wiley, New York (Unit: I and II)

3. L. Atwood and J. W. Steed, "Supramolecular Chemistry: A concise Introduction", 2nd edn., 2009, John Wiley & Sons Ltd., UK. (Unit: III)
4. J. M. Lehn, "Supramolecular Chemistry: Concepts and Perspectives", 1995, Wiley, VCH. (Unit: III)
5. R. M. Roat-Malone, "Bioinorganic Chemistry", 2002, John Wiley & Sons. (Unit: IV)
6. J. P. Collman, L. S. Hegedus, J. R. Norton and R. G. Finke, Principles and Applications of Organo- transition Metal Chemistry, University Science Books, California, 1987. (Unit: V)

Book for Reference:

1. B. Douglas, D.H.Me Daniel and J.J. Alexander, "Concepts and Models of Inorganic Chemistry", 2001, John Wiley and Sons, New Delhi.

Website and e- Learning Sources

1. https://www.scribd.com/document/699180174/Adamson-Rule
2. http://debracollege.dspaces.org/bitstream/123456789/430/1/bioinorganic_chemistry_-_a_sh_ort_course_r._m._roat-malone.pdf
3. https://www.researchgate.net/profile/Shafikul-Islam-2/post/Review_publications_of_inorganic_supramolecular_chemistry2/attachment/60ec00f36160740001e98586/AS%3A1044667185512461%401626079474774/download/Supramolecular+Chemistry+2e+by+Jonathan+W.+Steed.pdf
4. https://dokumen.pub/organotransition-metal-chemistry-1nbsped-9789350431696-9788184888362.html

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	recognize the concept and applications of inorganic photochemistry.	**K1**
CO-2	infer the photocatalytic reactions and mechanisms on solid surface and their potential applications in semiconductor, solar energy conversion and carbon dioxide reduction.	**K2**
CO-3	have a solid understanding of the key ideas and list a few applications for supramolecular chemistry.	**K3**
CO-4	realize the characteristics and mode of action of metal-containing molecules used for therapy and diagnosis in medicine.	**K4**
CO-5	understand the role of metals in drug discovery, design and development, and apply this knowledge to develop novel metal-based therapeutics.	**K5**
CO-6	analyze and interpret advanced concepts in inorganic chemistry and diverse applications of inorganic materials.	**K6**

Semester	Course code	Title of the Course			Hours	Credits
IV	P25CH16	Inorganic Chemistry – IV			6	5
(COs)	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %

Mapping Correlation	Low	Medium	High	No Correlation
Level of Correlation	1	3	9	0

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Inorganic Chemistry - IV course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Inorganic Chemistry - IV course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	ORGANIC CHEMISTRY - IV				P25CH17
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	IV	Lecture	6	5

Course Description

This course helps to master the basic knowledge of retro synthetic analysis and synthetic strategies and a comprehensive study of various spectroscopic techniques related to NMR, UV, IR and Mass spectrometry. It also elaborates the study of carbohydrates and photochemistry.

Objectives of the course

- To impart knowledge of retro synthetic analysis and synthetic strategies.
- To know the importance of photochemical reactions and ESR spectroscopy
- To learn about the applications of NMR and ^{13}CMR of organic compounds
- To understand the applications of UV, IR, and Mass spectrometry.
- To study the structure of the organic compounds and about the importance of carbohydrate

Course Outline

UNIT-I: Retro Synthesis and Synthetic Strategies (18 Hours)

1.1. Introduction: The Disconnection protocol-Synthetic problems-starting material is provided-No starting material is specified.

1.2. Protecting groups: Introduction- principle, the need of protecting groups-Common protecting groups for alcohols, carbonyls (aldehydes and ketones- Acyclic acetyls as protecting groups for carbonyl compounds), and amines.

1.3. Disconnection approach and synthetic strategies: relay and convergent synthesis- linear synthesis. Introduction to synthons, synthetic equivalents - target molecule - Umpolung - designing synthesis by disconnection approach.

1.4. Functional group interconversions: The importance of the order of events in organic synthesis C-C disconnections – Diels-Alder reaction and Robinson annulation – chemo selectivity (guidelines).

UNIT-II: UV-Visible and Infrared Spectroscopy (18 Hours)

2.1. UV-Visible: Basic principles of electronic transitions - applications of UV-visible spectroscopy - woodward-fiescher scott rules - applications to conjugated dienes, trienes, polyenes -α, β unsaturated carbonyl compounds. Conjugated cyclic ketones and acetophenones - aromatic hydrocarbons and heterocyclic systems - differentiation of position isomers and cis-trans isomers.

2.2. Infrared: Problems Molecular vibrations - stretching vibrations - symmetric and asymmetric - bending vibrations - rocking, scissoring, wagging and twisting - finger print region - characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds - alcohols, ethers, phenols and amines-Carbonyl compounds effect of hydrogen bonding (inter and intra molecular) and solvent effect on vibrational frequencies - overtones -fermi resonance. Calculation of double bond equivalents and its application in structural elucidation,

UNIT-III: NMR and ^{13}C NMR Spectroscopy (18 Hours)

^{1}H NMR spectroscopy: introduction - chemical shift, shielding, deshielding, chemical and magnetic non-equivalence of protons - spin-spin splitting - coupling constant - dependence of J on dihedral angle - vicinal and germinal coupling - karplus equation-factors influencing chemical shift - first and second order proton - simplification of complex. Spectra- double resonance techniques - contact shift reagents - chemical spin decoupling of exchangeable protons (OH, SH, COOH, NH, NH_2) - Nuclear Overhauser Effect 2-D techniques (COSY, NOESY and ROSY).

^{13}C NMR spectroscopy: Basic principles - FT - NMR relaxation - broad band decoupling - off resonance decoupling and calculation of chemical shift for simple aliphatic (olefin, alkynes, carbonyl carbon) and aromatic compounds - conformation and chemical shift correlation peak assignments. Importance of NOE phenomenon in ^{13}C spectroscopy.

UNIT-IV: Organic Photochemistry and Electron Spin Resonance Spectroscopy (18 Hours)

Fundamental concepts - Jablonski diagrams - photosensitization – photochemical reactions - photo reduction - photo oxidation, photo rearrangements - di-ᴨ-methane rearrangement, photo reactions of ketones and enones – Norrish type I and II reactions - Paterno Buchi reaction - barton reactions - photochemistry of alkenes, dienes – photo addition reactions, photo chemistry aromatic compounds.

ESR: Basic principles - comparison between ESR and NMR spectroscopy – hyperfine splitting - calculation of unpaired electron density on an atom in a delocalized system (C_6H_6 -, p-xylene anion, naphthalene radical ion) - structure of methyl radical, p-benzoquinone radical anion.

UNIT-V: Mass spectroscopy and Carbohydrate (18 Hours)

5.1. Mass spectroscopy: Introduction - ion production – factors affecting fragmentation, ion analysis - ion abundance - base peak, isotopic peak, meta stable peak, parent peak - fragmentation of organic compounds with respect to their structure determination of

common functional groups - molecular ion peak – McLafferty rearrangements. Nitrogen rule - high resolution mass spectroscopy.

5.2. Carbohydrate: Classification, Monosaccharides: Aldoses & Ketoses, monosaccharides (pyranose, furanose, chair, and boat conformations), Stability of Glycosidic Bonds, Disaccharides, and Oligosaccharides. Structural Polysaccharides: Cellulose, hemicellulose, pectin, lignin, chitin. Storage Polysaccharides: Starch, glycogen, inulin. Photosynthesis: Reaction for biosynthesis of glucose

Teaching Methodology: Interactive videos, PPT, demonstration and creation of models

Book for Study:

1. "Organic Photo Chemistry and Pericyclic reaction", M.G. Arora.
2. Organic Reactions and Orbital symmetry, T.L. Gilchrist and R.C. Storr. Cambridge, 1979.
3. The Conservation of Orbital symmetry, R.B. Woodward and R. Hoffmann, Academic Press, 1970.
4. Photochemistry and Pericyclic reactions. Jagdamba Singh and Jaya Singh New Age International, 2005.
5. Organic Spectroscopy - Principles and Applications, Jag Mohan -Narosa, 2009.
6. Elementary Organic Spectroscopy (Principles and Chemical Application). Y. R. Sharma, S. Chand, 2005.
7. Organic Spectroscopy, William Kemp Macmillan, 2008.
8. Spectroscopy of Organic Compounds - P.S. Kalsi - New Age International, 2012.
9. O. P. Agarwal, "Chemistry of Organic Natural Products", Volume I & II, Goel Publishers, 2014.

Book for Reference

1. Structure and Mechanisms, F. Carey, R. Sundberg, "Advanced Organic Chemistry. Part-A". 4th Ed., Kluwer Publishers, 2000.
2. Michael B. Smith, J. March, "March's Advanced Organic Chemistry", John Wiley & Sons, 6th Ed., 2007.
3. J. Clayden, N. Greeves, P. Wothers, "Organic Chemistry", Oxford University Press, 2001.
4. J. Mc. Murry, "Organic Chemistry", Brooks/Cole publisher, 5th Ed., 2000.
5. M. B. Smith, "Organic Synthesis', Academic Press, Elsevier, 3rd Ed., 2010

Website and e-learning source:

1. https://www.udemy.com/course/introductory-organic-chemistry-spectroscopy/?srsltid=AfmBOorYZyVp35qTQmby5276uNo1IS1w-7w8-gc3jtOnykazRRyK6Kvu
2. https://onlinecourses.nptel.ac.in/noc22_cy45/preview

3. https://www.udemy.com/course/ochemnmr/?srsltid=AfmBOopcFo2a-tVJJ33IoiIQ0CA_AkX4Gn1pd5dRUvIPcZBHOrkoTvn5&couponCode=ST4MT240225A
4. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/intro1.htm

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire knowledge of the principles, techniques, and applications the ESR and NMR, spectroscopy for structural elucidations, concepts and applications of UV-Vis, IR, and Mass spectroscopy.	**K1**
CO-2	understand applications of pericyclic reactions,	**K2**
CO-3	apply knowledge to the structural and stereo chemical implications on photochemical reactions.	**K3**
CO-4	analyze the structure of the organic compounds	**K4**
CO-5	evaluate biological activity of carbohydrate and organic compounds	**K5**
CO-6	create insights into the pericyclic mechanisms.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
IV	**P25CH17**	**Organic Chemistry – IV**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Organic Chemistry-IV course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Organic Chemistry-IV course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	PHYSICAL CHEMISTRY – III				P25CH18
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	IV	Lecture	6	5

Course Description

This course provides an in-depth understanding of electrochemical principles, surface chemistry, and their applications in energy storage, catalysis, and industrial processes. The course covers theoretical and experimental aspects of electrochemical systems, electrode kinetics, adsorption phenomena, and catalytic mechanisms, equipping students with the necessary skills to analyze and apply electrochemical techniques in scientific and technological domains.

Objectives of the course

- Understand electrochemical principles, including EMF measurements, electrode equilibria, and energy storage systems.
- Learn electro kinetic phenomena, electrode reaction kinetics, and applications of electrochemistry in corrosion prevention and power storage.
- Gain knowledge of electroanalytical techniques such as voltammetry, polarography, and amperometric titrations for chemical analysis.
- Explore surface chemistry concepts, adsorption isotherms, micelles, and their applications in chemical processes.
- Study heterogeneous and photo catalysis mechanisms, their industrial applications, and the role of semiconductor catalysts.

Course Outline

Unit I: Electrochemistry I **(18 Hours)**

1.1 Theories of Electrolytic Conductance and Applications: Arrhenius ionization theory, Debye-Hückel theory, Debye-Hückel-Onsager equation and its verification, Debye-Falkenhagen and Wien effects, Debye-Hückel limiting law, and applications in solubility determination and dissociation constants.

1.2 Ion-Selective Electrodes and pH Measurement: Ion selective electrodes - crystalline and non-crystalline electrodes - glass electrode for pH measurements, mechanism of electrode response and evaluation of selectivity coefficient.

1.3 Energy Storage Systems Electrochemical energy-storage System-Primary and secondary batteries – H_2-O_2 and Hydrocarbon-oxygen fuel cells.

Unit II: Electrochemistry II (18 Hours)

2.1 Electrical Double Layer and Electro-Kinetic Phenomena: Electrical double layer concepts - electrocapillary phenomena - Lipmann's equation – surfactants - zeta potential, and electrokinetic applications. Structural models include Helmholtz-Perrin, Gouy-Chapman, and Stern models, along with their applications and limitations.

2.2 Electron Transfer and Electrode Reaction Kinetics: Electron transfer dynamics - Marcus theory – tunneling - charge transfer rates, current density, Butler-Volmer and Tafel equations, polarization - overvoltage, and mechanisms of hydrogen and oxygen evolution reactions.

2.3 Applications of Electrochemistry: Metal electrodeposition, corrosion and passivity, Pourbaix and Evans diagrams, corrosion prevention methods, power storage systems and photovoltaic cells — construction and functioning.

Unit III: Electrochemistry – III (18 Hours)

3.1 Electroanalytical Methods and Polarography: Principles and applications of polarography - dropping mercury electrode (DME) - Ilkovic equation - half-wave potential, and polarographic cell operation. Techniques include DC polarography, pulse polarography (normal, differential, square wave), and stripping methods (cathodic and anodic).

3.2 Voltammetry and Amperometric Titrations: Voltammetric techniques including linear sweep and cyclic voltammetry, polarographic currents, and effects of dissolved oxygen. Principles, techniques and advantages of amperometric titrations in chemical analysis.

3.3 Coulometric and Electrogravimetry: Coulometry principles, Faraday's laws, types of coulometers, coulometric titrations, and electrogravimetry techniques.

Unit IV: Surface chemistry (18 Hours)

4.1 Surface Chemistry and Adsorption Phenomena: Adsorption of gases on solids, Gibbs adsorption isotherm, and adsorption isotherm models (Langmuir, BET, Freundlich, Temkin). Lannard-Jones plot-Surface area measurement and heat of adsorption.

4.2 Adsorption at Liquid Interfaces and Micelles: Adsorption on liquid surfaces - surface tension measurement - wetting, and contact angle at interfaces - soluble and insoluble films.

4.3 Micelles, Reverse Micelles, and Microemulsions: Structure, properties, and significance of micelles and reverse micelles, critical micelle concentration (CMC), bimolecular reactions in micellar solutions, and microemulsions in solubilization.

Unit V: Heterogeneous and Photo catalysis (18 Hours)

5.1 Heterogeneous Catalysis and Reaction Mechanisms: Kinetics of heterogeneous catalysis, Langmuir-Hinshelwood, Langmuir-Rideal, and Eley-Rideal mechanisms, and the

role of surfaces in catalysis. Semiconductor catalysis (n-type and p-type surfaces) and kinetics of surface reactions involving adsorbed species.

5.2 Photocatalysis and Industrial Applications: Types, mechanisms, and applications of photocatalysis. Industrial catalytic processes including Fischer-Tropsch reaction and ethylene hydrogenation.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study:

1. P. W. Atkins and J. de Paula, *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
2. A. J. Bard and L. R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2nd Ed., Wiley, 2001.
3. J. O'M. Bockris and A. K. N. Reddy, *Modern Electrochemistry*, Springer, 1998.
4. S. Glasstone, *Introduction to Electrochemistry*, Litton Educational, 1942.
5. D. A. McQuarrie, *Physical Chemistry: A Molecular Approach*, University Science Books, 1997.

Book for Reference:

1. J. J. Lingane, *Electroanalytical Chemistry*, 2nd Ed., Interscience, 1958.
2. K. J. Laidler, *Chemical Kinetics*, 3rd Ed., Pearson, 1987.
3. D. R. Crow, *Principles and Applications of Electrochemistry*, 4th Ed., CRC Press, 1994.
4. R. Parsons, *Handbook of Electrochemical Constants*, Butterworths, 1959.
5. G. A. Somorjai and Y. Li, *Introduction to Surface Chemistry and Catalysis*, 2nd Ed., Wiley, 2010.

Website and e-learning source:

1. MIT Open Course Ware - Electrochemistry & Surface Chemistry: https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/
2. NPTEL Online Courses - Electrochemistry & Catalysis: https://nptel.ac.in/courses/103106116
3. ChemLibreTexts - Electrochemistry & Surface Chemistry: https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps
4. Khan Academy - Electrochemistry: https://www.khanacademy.org/science/chemistry/oxidation-reduction

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	Recall fundamental principles of electrochemistry, surface chemistry, and heterogeneous catalysis.	**K1**
CO-2	Explain electrochemical reaction kinetics, adsorption models, and photocatalysis mechanisms.	**K2**
CO-3	Utilize electrochemical techniques for analytical applications and adsorption models in chemical separations.	**K3**
CO-4	Interpret electrochemical data, surface interactions, and catalytic mechanisms in heterogeneous reactions.	**K4**
CO-5	Assess the efficiency of electrochemical storage systems, corrosion prevention techniques, and industrial catalytic processes.	**K5**
CO-6	Develop new approaches for electrochemical energy storage, surface modification, and catalytic reaction optimization.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
IV	**P25CH18**	**Physical Chemistry – III**			**6**	**5**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**		**Medium**	**High**		**No Correlation**
Level of Correlation	**1**		**3**	**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO 2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Physical Chemistry - III course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Physical Chemistry - III course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	SUPRAMOLECULAR CHEMISTRY				P25CH19E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	II	IV	Lecture	6	3

Course description

This course explores the fascinating world of supramolecular chemistry including concepts, languages, implications of drug design, metalloreceptors and supramolecular catalysis and devices. It delves into non-covalent forces, molecular recognition, and self-assembly, crucial for understanding biological systems and developing new technologies. It focuses on the interactions between molecules and the resulting assemblies, including their applications in materials science, chemical biology and molecular machines and specifically in the development of nanoscience and technology.

Objectives of the course

- To cover fundamental concepts, diverse applications, molecular recognition, self-assembly, and the design of novel materials.
- To provide understanding of fundamental chemistry, synthesis, characterization, and diverse applications of metal-organic frame work.
- To learn co-receptor molecules and multiple recognition.
- To design and analyze supramolecular systems for catalytic applications.
- To encompass the principles, synthesis, characterization, and applications in various supramolecular devices.

Course Outline

UNIT-I: Concepts of Supramolecular Chemistry (18 Hours)

Concepts and languages of supramolecular chemistry – various types of non-covalent interactions – hydrogen bonds, CH…X interactions, halogen bonds – ππ interactions, non–bonded interactions – various types of molecular recognition. Crystal engineering of organic solids – hydrogen bonded supramolecular patterns involving water / carboxyl / halide motifs – concepts of different types of synthons based on noncovalent interactions – principles of crystal engineering and noncovalent synthesis – polymorphism and pseudopolymorphism – supramolecular isomorphism / polymorphism – crystal engineering of pharmaceutical phases.

UNIT-II: Metallo Organic Frameworks (Metallo Organic Frameworks)

(18 Hours)

Organometallic systems – combinations of different interactions to design molecular rods, triangles, ladders, networks, etc. – design of nanoporous solids – interligand hydrogen bonds in metal complexes – implications for drug design – crystal engineering of NLO materials, OLED.

UNIT-III: Supramolecular-I **(18 Hours)**

Co-receptor Molecules and Multiple Recognition Dinuclear and polynulclear metal ion cryptates – linear recognition of molecular length by ditopic coreceptors – heterotopic coreceptors – cyclophane receptors, amphiphilic receptors and large molecular cages – multiple recognition in metalloreceptors – supramolecular dynamics.

UNIT-IV: Supramolecular-II **(18 Hours)**

Supramolecular Reactivity and Catalysis Catalysis by reactive macrocyclic cation receptor molecules – catalysis by reactive anion receptor molecules – catalysis with cyclophane type receptors – supramolecular metallocatalysis – cocatalysis – catalysis of synthetic reactions – biomolecular and abiotic catalysis. 23 Supramolecular chemistry in solution – cyclodextrin, micelles, dendrimers, gelators – classification and typical reactions – applications.

UNIT-V: Supramolecular-III **(18 Hours)**

Supramolecular Devices Supramolecular devices and sensors – various types of supramolecular devices – an overview – supramolecular photochemistry – molecular and supramolecular photonic devices – light conversion and energy transfer devices – molecular and supramolecular electronic devices – electronic conducting devices – molecular wires, modified and switchable molecular wires – molecular and supramolecular ionic devices – tubular mesophases, molecular protonics – switching devices – electrophoto switch – ion and molecule sensors – role of supramolecular chemistry in the development of nanoscience and technology.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Books for Study

1. J. M. Lehn, Supramolecular Chemistry; VCH, Weinheim, Germany, 1995.
2. G. R. Desiraju, Crystal Engineering: The Design of Organic Solids; Elsevier, United States, 1989.
3. G. R. Desiraju, and T. Steiner, The Weak Hydrogen Bond in Structural Chemistry and Biology; Oxford University Press, Oxford, 1999.

Books for Reference

1. G. A Jeffrey, Introduction to Hydrogen Bonding; Oxford University Press: UK, 1997.
2. J. M. Lehn, Transition Metals in Supramolecular Chemistry; John Wiley and Sons: New York, 1999.
3. G. R. Desiraju, Current Science; 2001, 81, 1038.

Website and e- Learning Sources

1. http://www.pubs.acs.org/journals/cgdefu/index.html
2. http://www.rsc.org/Publishing/Journals/ce/index.asp

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	know fundamental principles, non-covalent interactions, design and analyze supramolecular systems.	**K1**
CO-2	equip with knowledge of metal-organic frame work fundamentals, synthesis, characterization, and applications.	**K2**
CO-3	discern the various co-receptor molecules and their multiple recognition.	**K3**
CO-4	explain the fundamental concepts of supramolecular chemistry and classify types of host-guest compounds and different supramolecular interactions.	**K4**
CO-5	understand fundamental concepts and design of supramolecular devices, and apply in materials science, chemical biology, and nanotechnology.	**K5**
CO-6	explain concepts and non-covalent interactions, and apply knowledge to design and analyze supramolecular systems, including their applications in various fields.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
IV	**P25CH19E**	**Supramolecular Chemistry**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	9
CO4	9	9	3	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	48	36	36	24	24
Weighted percentage of Course contribution to POs	100 %	88 %	66 %	66 %	44 %	44 %
Mapping Correlation	**Low**	**Medium**		**High**		**No Correlation**
Level of Correlation	**1**	**3**		**9**		**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,PO2,PO3,PO4	PO5,PO6,	--	--
CO2/ K2	PO1,PO3,PO4	PO2, PO5,PO6,	--	--
CO3/ K3	PO1,PO2,PO3,	PO4,PO5	PO6	--
CO4/ K4	PO1,PO2, PO5	PO3, PO4,PO6	PO3	
CO5/ K5	PO1,PO2	PO3, PO5	PO2,PO6	--
CO6/ K6	PO1,PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	%of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	2	1	1	3		5	20
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1			1	4		2	08
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Supramolecular Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Supramolecular Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	DYES AND PIGMENTS				P25CH19E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	II	IV	Lecture	6	3

Course Description

This course explores drug mechanisms, therapeutic uses, side effects, and synthesis methods. It also examines dye nomenclature, color-structure relationships, fiber-dye interactions, and addresses environmental concerns related to dye toxicity. Laboratory work includes synthesis and analysis of drugs and dyes.

Objectives of the course

- To familiarize students with the mode of action of drugs.
- To understand the uses and the side effects of certain drugs for various diseases.
- To study the synthesis of different drugs
- To study the nomenclature and characteristics of dyes.
- To study the concept of colour and its relation to chemical structure.
- To familiarize the students with the types of fibers, the application of dyes, and how the dyes are attached to them.
- To familiarize the students with the synthesis of some representative dyes.
- To create an awareness of the current concern about the toxicity of dyes and their effect on ecology.

Course Outline

Unit-I: Introduction to dyestuff chemistry (18 Hours)

Definition of dyes, properties (colour and fastness). Important milestones in the development of synthetic dyes. Nomenclature of commercial dyes with at least one example. Suffixes – G, O, R, B, 6B, L, S; colour index and colour index number.

Unit-II: Classification of dyes based on constitution (18 Hours)

Nitro dyes – Naphthol Yellow S

i. Nitroso dyes – Gambine Y
ii. Azo dyes – (a) Monoazo dyes – Orange IV, (b) Disazo dyes – Congo Red, (c) Trisazo dyes – Direct Deep Black
iii. Diphenylmethane dyes – Auramine O
iv. Triphenylmethane dyes-(a) Diamines – Malachite Green, (b) Triamines – Crystal Violet (c) Phenols – Phenolphthalein

v. Heterocyclic dyes – (a) Xanthenes – Eosine (b) Azines – Safranine T (c) Thiazines – Methylene Blue
vi. Anthraquinone dyes - Alizarin, Alizarin Cyanine Green G, Indanthrone
vii. Indigoid dyes - Indigo
viii. Phthalocyanines - Monastral Fast Blue BS

Unit-III: Classification of dyes based on application (18 Hours)

Definition, fastness properties, and applicability on substrates, examples with structures.
(a) Acid dyes – Orange II, Alizarin Cyanine Green G.
(b) Basic dyes – Crystal Violet, Bismark Brown.
(c) Direct Cotton Dyes – Chrysophenine G.
(d) Azoic dyes – Diazo components: Fast Red B Base, Fast Blue B Base; Coupling components: Naphthol AS, Naphthol AS-G.
(e) Mordant dyes – Eriochrome Black T, Alizarin.
(f) Vat dyes – Indigo, Indanthrene.
(g) Disperse dyes–Celliton Scarlet B, Disperse Yellow 6G
Colour and chemical constitution of dyes: Absorption of visible light, colour of wavelength absorbed and complementary colour, chromogen, chromophore, auxochrome, bathochromic and hypsochromic shifts.
Relation of colour to resonance in the following classes of dyes: Azo,Triphenylmethane, Anthraquinone.

Unit-IV: Organic Pigments (18 Hours)

General idea, the difference between dyes and pigments. Important characteristics of organic pigments, toners, and lakes. Classification of organic pigments with suitable examples, i.e. ionic pigments (lakes of acid and basic dyes), nonionic pigments (azo, indigoids, anthraquinone), uses of pigments. Synthesis of specific dyes and their uses
(i) Orange IV from sulphanilic acid
(ii) Bismark Brown from m-phenylenediamine
(iii) Malachite Green by using benzaldehyde and N, N-dimethylaniline
(iv) Methylene Blue by using 4-amino-N, N dimethylaniline, and N, N dimethylaniline
(v) Congo Red from nitrobenzene
(vi) Eriochrome Black T from β – naphthol
(vii) Alizarin from anthraquinone
(viii) Indigo from aniline
(ix) Indanthrene from anthraquinone
(x) Disperse Yellow 6G from benzanthrone

Unit-V: Types of fibers and classes of dyes (18 Hours)

Introduction to the following types of fibers with structures and classes of dyes applicable to these fibers: Cotton, wool, silk, and polyester.

Forces binding dyes to the fibers: Ionic forces, hydrogen bonds, Van der Waals forces, and covalent linkages.

Basic operations involved in a dying process: Preparation of fiber for dyeing, preparation of the dye bath, application of the dye, and finishing

Ecology and toxicity of dyes: Brief idea of environmental pollution and health effects due to dyes.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration.

Book for Study:

1. Pharmacology and pharmaceutics Vol.I and II, Satoskar
2. Textbook of organic, medicinal, and pharmaceutical chemistry, Wilson and Gisvold
3. Textbook of medicinal chemistry, William O. Foye and David A. William
4. Medicinal chemistry, G. R. Chatwal
5. Chemistry of synthetic dyes, Vol. I to VI, K. Venkataraman
6. Chemistry of synthetic dyes and pigments, H. A. Lubs

Book for Reference:

1. Colour Chemistry, H. Zollinger
2. Colour Chemistry, R. L. M. Allen
3. Unit process, Groggins
4. Synthetic dyes, M. S. Yadav
5. Physical Chemistry of dyeing, Thomas Vickerstaff

Website and e- Learning Sources

1. https://archive.mu.ac.in/syllabus/4.11%20App%20Com%20Drugs%20and%20Dyes.pdf
2. https://catalog.northeastern.edu/course-descriptions/phsc/
3. https://bulletin.auburn.edu/coursesofinstruction/dbps/

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	acquire knowledge in the various classifications of dyes, and organic pigments.	**K1**
CO-2	understand various fundamental principles of dyeing processes, and pigment chemistry.	**K2**
CO-3	apply knowledge to the practical applications of synthetic and natural dyes in various industries, knowledge of organic pigments in formulating products in fields like textiles, paints, and cosmetics.	**K3**
CO-4	analyze the interaction between dyes/pigments and various substrates/materials.	**K4**
CO-5	evaluate the advancements in dye and pigment technology, including sustainable and eco-friendly practices.	**K5**
CO-6	create innovative dyeing techniques and organic pigments with enhanced properties and environmental compatibility.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
IV	**P25CH19E**	**Dyes and Pigments**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %
Mapping Correlation	**Low**	**Medium**		**High**	**No Correlation**	
Level of Correlation	**1**	**3**		**9**	**0**	

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	**Level of Correlation**			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Dyes and Pigments course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Dyes and Pigments course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	ANALYTICAL CHEMISTRY				P25CH19E
Course Type	Year	Semester	Category	Hours /Week	Credits
Elective	II	IV	Lecture	6	3

Course Description

This course integrates analytical chemistry techniques, including chromatography (GC, HPLC), thermoanalysis, molecular luminescence spectrometry, and electron imaging. It emphasizes error analysis, data treatment, computational chemistry, molecular modeling, and their applications in drug design and material characterization.

Objectives of the course

- Understand error analysis, data treatment, and the principles of atomic spectroscopy for accurate chemical analysis.
- Learn the fundamentals of chromatography techniques, including GC, HPLC, and their applications in chemical separations.
- Explore thermoanalytical methods, molecular luminescence spectrometry, and electron imaging techniques for material characterization.
- Gain knowledge of computer applications in chemistry, including C programming, software tools, and data analysis.
- Study molecular modeling principles, computational chemistry techniques, and their applications in drug design and conformational analysis.

Course Outline

UNIT-I: Error Analysis and Instrumental Methods of Analysis (18 Hours)

1.1 Error Analysis and Data Treatment: Statistical concepts in quantitative measurements—mean, median, standard deviation, precision, and accuracy. Types of errors, Gaussian distribution, confidence intervals, hypothesis testing (t-test, F-test, Q-test). Regression analysis and quality control methods.

1.2 Reliability of Analytical Results and Calibration Methods: Sensitivity, selectivity, and detection limits in analytical methods. Calibration techniques: Internal standards and standard addition methods. Quality assurance in analytical chemistry and reliability of instrumental analysis results.

1.3 Atomic Spectroscopy Techniques: Principles, theory, instrumentation and applications of Atomic Absorption Spectroscopy (AAS) and Flame Photometry. Instrumentation: Atomization methods (flame, furnace), radiation sources (hollow cathode lamps), detectors, and interference effects. Applications in chemical analysis.

UNIT-II: Chromatography (18 Hours)

2.1 Fundamentals of Chromatographic Techniques: Principles of separation, mobile and stationary phases. Ion-exchange, paper, thin-layer (TLC), and column chromatography: methodology, retention parameters (K_d, t_R, R_f), and applications in chemical analysis.

2.2 Gas Chromatography (GC) and GC-MS: Principles of gas-liquid chromatography (GLC), instrumentation (carrier gas, injection systems, columns, and stationary phases), and detectors (TCD, FID). Overview of GC-MS techniques, instrumentation, and applications in chemical analysis.

2.3 High-Performance Liquid Chromatography (HPLC) and Advanced Techniques: Principles and classification (normal-phase and reverse-phase HPLC), instrumentation (pumps, columns, detectors), and applications in pharmaceuticals, environmental, and biomolecular analysis. Introduction to UHPLC and Supercritical Fluid Chromatography (SFC) with applications.

UNIT-III: Thermoanalytical Methods and Molecular Luminescence Spectrometry (18 Hours)

3.1 Thermoanalytical Methods Techniques: Principles, instrumentation, and applications of TGA, DTA, and DSC in material characterization and purity testing. Comparison of TGA vs. DTA and DSC. Thermometric titrations: principles and instrumentation.

3.2 Surface Characterization and Electron Imaging Techniques: Principles, instrumentation, and applications of SEM, TEM, XRD, XPS, and AFM for material analysis and surface characterization.

3.3 Molecular Luminescence Spectrometry: Principles and instrumentation of fluorescence and phosphorescence spectrometry. Fluorometers and spectrofluorometers: components and standardization. Flow cytometry: principles and applications. X-ray diffraction (XRD): principles, instrumentation, and analytical applications.

UNIT-IV: Computer Applications in Chemistry (18 Hours)

4.1 Introduction to C language: Introduction to computers and computing–World Wide Web-E-journals–search engines for chemistry. Introduction to C language - Structure of C program - Control statements-if statement– Loops-while and for loops -recursion.

4.2 Applications: Examples of simple chemistry Programmes:

1. Conversion of Celsius temperature to Kelvin temperature
2. Applications of Beer-Lambert Law.
3. Linear least square-Fit logkvs1/Tplot to get Arrhenius parameters.
4. Determination of Anharmonicity constant and dissociation energy calculation.

5. Use of CHEMDRAW and ORIGINLAB software

UNIT-V: Molecular Modeling (18 Hours)

5.1 Introduction to Molecular Modeling: Fundamental concepts, importance, and applications. Coordinate systems (Cartesian and internal), structural parameters (bond lengths, angles, torsions). Molecular representations: stick models, space-filling, and wireframe models.

5.2 Potential Energy Surfaces and Molecular Mechanics: Concept and significance of PES, energy minimization techniques. Molecular mehanics principles, force fields (MM2, MM3, AMBER, CHARMM, OPLS), and parameterization. Energy minimization methods: steepest descent, conjugate gradient, Newton-Raphson. Molecular mechanics-application and parameterization - advantages and limitations of force fields.

Teaching Methodology: Chalk & Talk, PPT, videos, and demonstration

Book for Study

1. Willard, Merrit, Dean, and Settle, *Instrumental Methods of Analysis*, 6th Ed., CBS Publishers, 1986.
2. Skoog, D. A., West, D. M., and Holler, P. J., *Fundamentals of Analytical Chemistry*, 7th Ed., Harcourt College Publishers.
3. R. Stock and C. B. F. Rice, *Chromatographic Methods*, Chapman and Hall, New York.
4. V. K. Srivastava and K. K. Srivastava, *Introduction to Chromatography*, 2nd Ed., S. Chand & Co., New Delhi, 1981.
5. Sharma, S. G., Schulman, *Introduction to Fluorescence Spectroscopy*, Wiley-Interscience, 1999.
6. E. Balaguruswamy, *Programming in ANSI C*, 2nd Ed., Tata McGraw Hill, 1999.
7. R. Leach, *Molecular Modeling Principles and Applications*, 2nd Ed., Prentice Hall, 2001.
8. W. B. Smith, *Introduction to Theoretical Organic Chemistry and Molecular Modeling*, John Wiley, 1996.
9. Tim Clark, *A Handbook of Computational Chemistry*, John Wiley, 1985.

Book for Reference

1. H. H. Willard, L. L. Merritt, J. A. Dean, *Instrumental Methods of Analysis*, 7th Ed., CBS Publishers, 1988.
2. J. D. Winefordner, *Instrumentation in Analytical Chemistry*, John Wiley, 1981.
3. D. Harvey, *Modern Analytical Chemistry*, McGraw Hill, 2000.
4. R. Kellner, J. M. Mermet, and M. Otto, *Analytical Chemistry: A Modern Approach to Analytical Science*, Wiley-VCH, 2004.
5. I. N. Levine, *Quantum Chemistry*, 6th Ed., Pearson, 2008.

Website and e- Learning Sources

1. MIT OpenCourseWare - Analytical Chemistry & Spectroscopy: https://ocw.mit.edu/courses/chemistry/
2. NPTEL Online Courses - Analytical Techniques & Molecular Modeling: https://nptel.ac.in/courses/104108073
3. ChemLibreTexts - Chromatography & Spectroscopy: https://chem.libretexts.org/
4. Khan Academy - Spectroscopy & Computational Chemistry: https://www.khanacademy.org/science/organic-chemistry/spectroscopy-jay

Course Outcome		
CO. No.	**CO-Statement** **On successful completion of this course, students will be able to**	**Cognitive Level (K-Level)**
CO-1	Recall fundamental concepts in analytical chemistry, including spectroscopic, chromatographic, and computational techniques.	**K1**
CO-2	Explain error analysis, instrumental methods, and the principles behind molecular modeling and computer applications in chemistry.	**K2**
CO-3	Utilize chromatographic, spectroscopic, and computational techniques to analyze chemical systems and solve real-world problems.	**K3**
CO-4	Interpret analytical data, evaluate instrumental results, and differentiate between various analytical and computational methods.	**K4**
CO-5	Assess the efficiency and limitations of analytical instruments, modeling techniques, and computer applications in chemistry.	**K5**
CO-6	Develop new analytical approaches, computational models, and software-based solutions for chemical research.	**K6**

Semester	**Course code**	**Title of the Course**			**Hours**	**Credits**
IV	**P25CH19E**	**Analytical Chemistry**			**6**	**3**
(COs)	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	9	9	9	9	3	3
CO2	9	3	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	3	9	3	9	3
CO5	9	9	3	3	3	3
CO6	9	9	3	3	3	3
Weightage	54	42	42	30	24	18
Weighted percentage of Course contribution to POs	100 %	77 %	77 %	55 %	44 %	33 %

Mapping Correlation	**Low**	**Medium**	**High**	**No Correlation**
Level of Correlation	**1**	**3**	**9**	**0**

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6,	--	--
CO 2 / K2	PO1, PO3, PO4	PO2, PO5, PO6,	--	--
CO 3 / K3	PO1, PO2, PO3,	PO4, PO5	PO6	--
CO 4 / K4	PO1, PO2, PO5	PO3, PO4, PO6	PO3	
CO 5 / K5	PO1, PO2	PO3, PO5	PO2, PO6	--
CO 6 / K6	PO1, PO2	PO3, PO4, PO5, PO6	--	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non-Scholastic Marks C5	CIA Total	% of Assessment
	T1 5 Marks	T2 6 Marks	Assignment 4 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	1	1		4		3	12
K2	1	1	1	1	3		4	16
K3	1	1	1	1	3		4	16
K4	1	1	1	1	4		4	16
K5		1		1	2		2	08
K6	1	1		1	4		3	12
Non-Scholastic	--	--	--	--	--		5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The COs and POs for the Analytical Chemistry course in the M.Sc. Chemistry Programme is effectively matched by the Course Teacher.

The COs and POs for the Analytical Chemistry course in the M.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the HoD

Programme Code	Course Title				Course Code
CHYPG1985	PROJECT WORK				P25CH20
Course Type	Year	Semester	Category	Hours /Week	Credits
Core	II	IV			5

Course description

This course offers a comprehensive introduction to research methodologies, emphasizing problem identification, research design, and chemical literature surveys. Students will engage in project work, including data collection and analysis, and develop skills in scientific writing and effective presentation. Ethical considerations in research are also addressed.

Objectives of the course

- Understand the fundamentals of research, including definitions, hypotheses, and types of educational research.
- Identify and formulate research problems, applying ethical considerations in research design
- Conduct a comprehensive chemical literature survey using various search techniques.
- Execute a research project, encompassing problem identification, methodology selection, data collection, and analysis.
- Develop skills in scientific writing and effective presentation, adhering to appropriate referencing styles.

Introduction and Fundamentals of Research

Research: Definition - search for knowledge - role of theory-research hypothesis, and null hypothesis - populations and sampling - purposes of research - types of educational research: fundamental research - applied research - action research - descriptive research, assessment, and evaluation.

Problem identification and Research Design

Scientific research problem: Definition, objectives, purposes, and components of research problem, ethics in research.

Chemical Literature Survey

Introduction to the chemical literature- non-patent primary literature: communications, articles, reviews, conference papers, reports, abstracts, and preprints- chemical patents.

Searching using text: beyond web search engines, searching by structure and substructure.

Project Work-Lab

Identification of research problem - collection of materials -preliminary analysis - finalizing the methodology - execution of the research work - collection of data and evidence - finalizing the results.

Compilation of Report

Scientific Writing and Effective Presentation: Requirement of scientific communications: eliminating wordiness and jargon-tautology, redundancy, imprecise words, superfluous phrases - style of writing footnotes, and end notes- referencing styles-bibliography-journal abbreviations (CAS source index) abbreviations used in scientific writing-Effective presentation: slide presentation and poster presentation- Report preparation:

Format of the Dissertation Report

I. Title Page
- ❖ Title
- ❖ Author's name and institutional affiliation
- ❖ Running head

II. Introduction (no heading)
- ❖ Statement of the problem
- ❖ Background/review of literature
- ❖ Purpose and rationale/hypothesis

III. Method
- ❖ Apparatus or instrumentation
- ❖ Procedure

IV. Results
- ❖ Tables and figures, as appropriate (these follow the author note)
- ❖ Statistical/ analytical presentation

V. Discussion
- ❖ Support or nonsupport of hypotheses
- ❖ Practical and theoretical implications
- ❖ Summary and Conclusions

VII. References

VIII. Appendix (if appropriate)

Books for Study

1. Best, J. W., & Kahn, J. V. (2006). Research in Education, (10th Ed.). Pearson Education Inc.
Unit I Chapters 1
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3. Coghill, A. M., & Garson, L. R. (editors). (2006). The ACS Style Guide: Effective Communication of Scientific Information, (3rd Ed.). American Chemical Society: Washington, DC, Oxford University Press.
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3. Dawson, C. (2019). Introduction to Research Methods: A practical guide for anyone undertaking a research project, (5th Ed.). Robinson.

Website and e-Learning Source

1. https://libguides.library.albany.edu/subject-gateway/chemistry