M.Sc. ORGANIC CHEMISTRY

PROGRAM OUTCOMES

PO1: Scientific Knowledge: Ability to build a strong foundation of knowledge, integrated with the latest developments in science and technology which help students develop critical thinking, reasoning, decision making in process of quality education.

PO2: Problem Analysis: Identify, formulate, and analyze complex scientific problems using the knowledge gained across various streams of science and technology.

PO3: Effective Communication: Ability to articulate ideas, communicate effectively using current tools in the field of ICT along with effective report writing and documentation.

PO4: Development of Skill and Attitude: Enabling the students with the required skill, right attitude, time management and self-discipline for prominent careers in industry, research institutes, and for further academic study.

PO5: Lifelong Learning and Social Responsibility: Recognize the need and ability to engage in lifelong learning and work effectively as an individual and as a member of a diverse team. Students get the ability to act with an informed awareness of issues to participate in civic life through volunteering.

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Program Specific Outcomes

PSO1	**Understands, identify and interrelate** with the background of organic reaction mechanisms, complex Stereochemical structures, molecular rearrangements, instrumental method of chemical analysis, and separation techniques.
PSO2	**Analyses** the importance of various elements in the periodic table, coordination chemistry and structure of molecules, properties of compounds, and structural determination of complexes using theories.
PSO3	**Gathers attention** about the physical aspects of atomic structure, dual behavior, reaction pathways with respect to time, various energy transformations, molecular assembly in nano-level, electrochemistry & infer their significance.
PSO4	**Learns, constructs, and analyses** the potential uses of analytical techniques, medicinal chemistry, and green chemistry.
PSO5	**Organize** and carry out experiments in the area of organic analysis, estimation, separation, derivative process, preparation, conductometric, potentiometric and solve spectral analysis.

COMMUNICATIVE COMPETENCE

Credits: 2 **Semester: I**
Course Code: MOC26101 **No. of lecture hours: 30**

Course Objective:

- To develop learners' competence in English communication for academic and professional contexts.
- To enhance oral and written communication skills with emphasis on clarity, confidence, and effectiveness.
- To prepare learners for real-world applications such as presentations, group discussions, job applications, and interviews.
- To cultivate professional etiquette in both verbal and non-verbal communication.
- To strengthen listening, speaking, reading, and writing skills for holistic communicative competence.

Course Outcome:

CO1: understand the significance, process, types, and barriers of communication, and apply strategies for effective verbal and non-verbal interaction.
CO2: demonstrate effective oral communication through voice modulation, presentation skills, and active participation in group discussions.
CO3: compose professional job applications, resumes, CVs and supporting documents for career opportunities.
CO4: exhibit skills to prepare for, attend and perform effectively in different types of interviews with confidence and professionalism.
CO5: demonstrate the ability to write ethically, summarize and paraphrase effectively, cite sources correctly, and produce professional abstracts.

Course Content	Hours Allotted	Pedagogy
Module I: English Communication (6 hours) • Communication: Significance, Features, Process, Types • Barriers to Communication and Strategies for Effective Communication • Non-verbal Communication: Types and Effective Use • Listening: Types, Importance and Tips for Effectiveness	2 2 1 1	Lectures/ PPT Presentations/ Listening exercises
Module II: Oral Communication (6 hours) • Oral Communication: Strategies for Effectiveness; Paralanguage: Stress, Tone, Volume, Pitch, Inflections, Pauses, Voice modulation. • Presentation Skills: Presentation types and tools, Visual Aids, Use of Connectives, Body language • Group Discussion: Purpose, Process, Do's and Don'ts, Helpful Expressions, Evaluation	2 2 2	Lectures/ Role play/ Presentations/ Group Discussions

Module III: Job Application (6 hours) • Job Application and Cover Letter • Resume and CV, Testimonials, References	2 4	Lectures/ PPT Presentations
Module IV: Interview (6 hours) • Types of Interviews • Preparing for an Interview • Attending the Interview • Interview Process	1 1 2 2	Lectures/ Mock Interview
Module V: Writing for Academic Purposes (6 hours) • Plagiarism: Ways to avoid it • Paraphrasing and Summarizing • References and Citations • Abstract Writing	1 2 2 1	Lectures/ PPT Presentations/ Specimen Sampling

Learning Resources	
1.	Grussendorf, Marion. *English for Presentations*. Oxford University Press, Oxford, 2007.
2.	Kumar, Suresh, and P. Sreehari. *Communicative English*. Orient Blackswan, New Delhi, 2019.
3.	Madhukar, R. K. *Business Communication*. 4th ed., Vikas Publishing House, New Delhi, 2024.
4.	Padhy, Kishore C., and Madhuchanda. *A to Z Interview*. Himalaya Publishing House, New Delhi, 2008.
5.	Robbins, Stephen P., and Philip R. Hunsaker. *Training in Interpersonal Skills: Tips for Managing People at Work.* 6th ed., Pearson, 2021.
6.	Thorat, Ashok, and M. Lokhanwala. *Enriching Oral and Written Communication in English.* Orient Blackswan, New Delhi, 2009.

INORGANIC CHEMISTRY-I

Credits: 4 **Semester: I**
Course Code: MOC26102 **No. of lecture hours: 60**

Objectives

- To impart knowledge of co-ordinate complexes, their reaction mechanisms, and their stabilities.
- To acquire the knowledge of symmetry and assign the same to the molecules.

Course Outcomes

- Understands the concept of bonding in metal complexes
- Interrelates 3-D structures of molecules with their symmetry elements
- Categorizes the mechanisms of inorganic complexes
- Analyses the stability of the complexes through equilibria
- Identifies the ligational aspects of diatomic molecules

Course Content	Hours allotted	Pedagogy
Module-01: Bonding in metal complexes-I	**12 hrs**	
• Crystal Field Theory: Salient features of CFT. Splitting pattern of d-orbital in regular Octahedral, tetrahedral, square planar, trigonal planar, and linear geometries.	5	Power point presentations / Lectures/ Assignments
• Jahn-Teller Theorem- tetragonal distortions, splitting pattern in elongated octahedral and compressed octahedral geometry.	2	
• Concept of weak field and strong field–Calculation of crystal field stabilization energies (CFSE's) in six coordinate (octahedral) and four coordinate (tetrahedral) complexes.	2	
• Types of magnetic behavior– paramagnetism, diamagnetism, ferromagnetism and anti-ferromagnetism – calculation of magnetic moments from spin only formula	3	
Module-02: Symmetry of molecules-I	**12 hrs**	
• Introduction to symmetry in Chemistry–Symmetry Operations	3	Power point presentations / Lectures/ Assignments
• Symmetry Elements: Rotational Axis of Symmetry and Types of Rotational Axes, Plane of Symmetry and types of Planes, Alternating Axis of Symmetry, Inversion Center and Identity Element.	4	
• More about Symmetry Elements-Molecular Point Groups: Definition and Notation of Point Groups (Schoenflies Notation)	2	
• Classification of Molecules into C_1, C_s, C_i, C_n, C_{nv}, C_{nh} Point Groups.	3	
Module-03: Reaction mechanism-I	**12 hrs**	
• Ligand substitution reactions: Energy profile of a reaction – Transition state or Activated Complex	2	Power point presentations / Lectures/ Assignments
• Labile and Inert Complexes. VBT Explanation of Lability and Inertness. Taube's Explanation of Lability and Inertness.	3	
• Types of substitution reactions: S_N^1: Substitution Nucleophilic Unimolecular Mechanism (Dissociative Mechanism), S_N^2: Substitution Nucleophilic Bimolecular Mechanism (Associative Mechanism), S_N^1CB: Substitution Nucleophilic Unimolecular	3	

via Conjugate Base Mechanism • Ligand substitution reactions in octahedral complexes: Aquation or Acid hydrolysis reactions, Factors affecting Acid Hydrolysis, Base Hydrolysis, Conjugate Base Mechanism, Evidence in favor of S_N1CB Mechanism, substitution reactions without breaking metal ligand bond.	4	
Module-04: Coordination equilibria	**12 hrs**	
• Solvation of metal ions- Binary complexes: Formation of binary metal complexes and their stability.	2	
• Types of Stability Constants– Step-wise and Overall stability constant, relation between them- trends and factors influencing Step-wise Stability Constants in the formation of cadmium ammine complex	2	
• Factors influencing the stability constants: (i) Ligand effects: Basicity, Substituent effect, Steric effect, Chelate effect (size and number of chelate rings), Macrocyclic effect; (ii) Metal ion effects: Ionic potential, Effective Nuclear charge and Atomic Number (Irving-William's Order), the geometry of metal ion and ligand	5	Power point presentations / Lectures/ Assignments
• Jahn-Teller effect on Stability constants of metal complexes ($[Cu(en)_3]^{2+}$ complex)	1	
• Pearson's Theory of Hard and Soft Acids and Bases (HSAB), Applications of HSAB.	2	
Module-05: Ligational aspects of diatomic molecules	**12 hrs**	
• Metal Carbonyls: Carbon monoxide as a ligand, molecular orbital energy level diagram of CO, donor and acceptor molecular orbitals of CO; bonding modes of CO: terminal and bridging, bonding aspects of CO (σ-donor and π-acceptor properties)	4	Power point presentations / Lectures/ Assignments
• Evidence for multiple bonding from bond lengths and stretching frequencies, 18 valence electron rule and its application	3	
• Metal nitrosyls: NO as a ligand, molecular orbital energy level diagram of NO, donor and acceptor components; bonding modes of NO: terminal (linear, bent) and bridging; structural aspects of $[IrCl(PPh_3)_2(CO)(NO)]^+$ and $[RuCl(PPh_3)_2(NO)_2]^+$	4	
• Stereochemical control of valance in $[Co(diars)_2(NO)]^{2+}$ and $[Co(diars)_2(NO)(SCN)]^{1+}$	1	

Learning Resources:

Module-01:

1. J.E.Huheey, K. A. Keiter and R. L. Keiter, 1993, **Inorganic Chemistry** (4th Ed), Harper Cotton's College Publications.
2. G. L. Eichorn, Inorganic Biochemistry, **1982**, Vol 1, Elsevier.
3. R D Madan, G D Tuli and Wahid U Malik. **2011**. **Selected Topics in Inorganic Chemistry** (7th Ed), S Chand & Company Ltd.

Module-02:

4. Mark Ladd**,** 2000, **Symmetry and Group theory in Chemistry**, Marwood Publishers, London,Mark Ladd.
5. K.Veera Reddy, 1999, **Symmetry and Spectroscopy of Molecules** (1st Ed.), New Age International (P) Limited.

Module-03:

6. Mark Ladd, 2000, **Symmetry and Group theory in Chemistry,** Marwood Publishers, London.
7. K. Veera Reddy, 1999, **Symmetry and Spectroscopy of Molecules** (1st Ed), New Age International (P) Limited.
8. F.Albert Cotton, 2009, **Chemical Applications of Group Theory** (3rd Ed), Wiley India.

Module-04 & 05:

9. F.A.Cotton, G.Wilkinson, C.A.Murillo and M.Bochmann, 1999, **Advanced Inorganic Chemistry** (6th Edn), Wiley Interscience.
10. M. M. Taqui Khan and A. E Martell, 1974, **Homogeneous Catalysis by Metal complexes** Vol I, Academic Press NewYork.
11. D.F.Shriver, H.D.Kaerz and R.D.Adams, 1990, **The Chemistry of Metal Cluster Complexes.** Oxford University Press, NewYork.

ORGANIC CHEMISTRY-I
(Organic Reaction Mechanism, Stereochemistry & Natural Products)

Credits: 4 **Semester: I**

Course Code: MOC26103 **No. of lecture hours: 60**

Objectives

- To impart the knowledge of stereochemistry.
- To understand the mechanisms in organic reactions.
- To perceive the knowledge of reactive intermediates and apply the same for various molecular rearrangements.
- To understand the structural analysis of natural products.

Course Outcomes

- Develops the fundamentals of reactive intermediates and predict various steps involved in molecular rearrangements
- Understands and compares the organic reaction mechanisms
- Acquires knowledge of the 3D aspects of organic molecules
- Perceives the concept of conformational analysis
- Perceives the knowledge of structural determination of natural products

Course Content	Hours allotted	Pedagogy
Module-01: Reactive intermediates & Molecular Rearrangements	**12 hrs**	
• Generation, detection, structure, stability and reactions of Carbocations (Classical and Non-Classical) carbanions	2	Power point presentations / Lectures / Assignments
Carbenes, nitrenes, Free radicals, Benzyne	3	
Molecular rearrangements: Definition and classification. Molecular rearrangements involving electron deficient carbon: Allylic and Wolf rearrangement	2	
• Electron deficient nitrogen: Hofmann, Lossen, Curtius, Schmidt and Beckmann rearrangements	3	
• Electron deficient oxygen: Baeyer-Villiger oxidation Base catalysed rearrangements: Benzilic acid, Favourski, Sommlett-Hauser and Smiles rearrangement	2	
Module-02: Reaction mechanism-I	**12 hrs**	
Electrophilic addition to carbon- double bond: Stereoselective addition to carbon-carbon double bond; *anti*-addition: bromination and epoxidation followed by ring-opening. *Syn*-addition of OsO_4 and $KMnO_4$, Prevost and Woodward oxidation	4	Power point presentations / Lectures/ Assignments
Elimination reactions: E_2, E_1, E_1CB mechanisms. Orientation and stereoselectivity in E_2 eliminations. Pyrolytic syn elimination and α-elimination, elimination *Vs* substitution	4	
Determination of reaction mechanism: Energy profiles of addition and elimination reactions, transition states, product isolation and structure of intermediates, use of isotopes, chemical trapping and crossover experiments	4	

Module-03: Stereochemistry	**12 hrs**	
• Molecular symmetry and chirality: Symmetry operations and symmetry elements (C_n&S_n). Criteria for chirality and desymmetrization	2	
• Axial, planar and helical chirality, configurational nomenclature: Axially chiral allenes, spiranes, alkylidene cycloalkanes, chiral biaryls, and atropisomers Planar chiral ansa compounds and *trans*-cyclooctene. Helically chiral compounds.	4	Power point presentations / Lectures/ Assignments
• Topicity and pro stereoisomerism: Topicity of ligands and faces and their nomenclature, pro-R and pro-S	3	
• Resolutions by chiral chromatography and asymmetric transformation,	1	
• Determination of configuration in *E, Z*-isomers: Spectral, chemical methods of configuration determination of *E, Z*-isomers	2	
Module-04: Conformational Analysis (Acyclic Systems)	**12 hrs**	
• Introduction to conformational isomerism and concept of dynamic stereochemistry. Klyne-Prelog terminology for conformers and torsion angles	**1**	
• Conformational analysis of ethane, 1,2-disubstituted ethane derivatives like butane, dihalobutanes, halohydrin, ethylene glycol, butane-2,3-diol, amino alcohols, and 1,1,2,2-tetrahalobutanes. Conformations of unsaturated acyclic compounds: propylene, 1-Butene, acetaldehyde, propionaldehyde and butanone	**6**	Power point presentations / Lectures/ Assignments
• Conformational diastereoisomers and conformational enantiomers. Factors affecting conformational stability and conformational equilibrium: Attractive and repulsive interactions. Use of physical and spectral methods in conformational analysis	**3**	
• Conformational effects on the stability and reactivity of acyclic diastereoisomers, steric and stereoelectronic factors with examples	**2**	
Module-05: Natural Products	**12 hrs**	
• Isolation of natural products by steam distillation, solvent extraction and chemical methods.	1	
• Definitions, medical importance, occurrence, detections by various color tests, Classification of alkaloids and terpenoid, Isoprene rule, Special isoprene rule	3	Power point presentations / Lectures/ Assignments
• General methods in structural determination of terpenes	2	
• Structure determination and synthesis of α-terpeniol and camphor. Structure determination and synthesis of β- carotene.	3	
• General methods of structure determination of alkaloids. Structure determination and synthesis of papaverine	3	

Learning Resources:

Modules-01 & 02

1. Petersykes, **A Guidebook of Mechanism of Organic Chemistry** (6th Ed.), Pearson Education, India.
2. Jerry March 1992, **Advanced Organic Chemistry** (5thEd.), Wiley-India student edition
3. S. Mukherjee, 2007, **Mechanism and Structure in Organic Chemistry** (3rd Ed.), MacMillan Publishers India Limited

Modules-03 & 04:

1. Ernest L Eliel, Samuel H. Wilen, 2008, **Stereochemistry of Carbon compounds**, John Wiley & Sons INC.
2. D. Nasipuri, 2006, **Stereochemistry of Organic Compounds-Principles and Applications** (2ndEd.), New Age International publishers.
3. P S Kalsi, 2010, **Stereochemistry: Conformation & Mechanism** (7th Ed.), New Age International publishers

Module-05:

4. Finar, I.L. 2009. **Textbook of Organic Chemistry**. Vol II. 5th Edition. Pearson Publications.
5. Bhat, S.V. and Nagasampangi, B.A. 2009. **Chemistry of Natural Products**. New Delhi: New Delhi: Narosa Publishing House.
6. Kalsi, P.S. 1983. Chemistry **of Natural Products.** Kalyani Publishers.

PHYSICAL CHEMISTRY-I

Credits: 4 **Semester: I**
Course Code: MOC26104 **No. of lecture hours: 60**

Objectives

- To understand the thermodynamic properties of reactions.
- To study the nature of electrochemical cells and their applications
- To impart knowledge about the subatomic particles of matter.
- To acquire the knowledge of kinetic mechanism.
- To study the photochemical properties and their applications.

Course Outcomes

- Learns the classical status of thermodynamics
- Better understanding of Types of electrodes and their functions
- Perceives the postulates of quantum chemistry and to provide the fundamentals of quantum chemistry in terms of Schrodinger equation
- To learn kinetic theories and factors affecting reaction rates, complex reactions, fast reactions and adsorption reactions
- Distinguish different photochemical processes such as fluorescence, phosphorescence, photochemical decay processes of molecules

Course Content	Hours Allotted	Pedagogy
Module-01: Thermodynamics-I	**12 hrs**	
• Third law of thermodynamics: Evaluation of absolute entropies from heat capacity data for solids, liquids and gases, standard entropies and entropy changes of chemical reactions.	3	Power point presentations / Lectures/ Assignments
• Helmholtz and Gibbs free energies (A and G), A and G as a criterion for equilibrium and spontaneity, physical significance of A and G, driving force for chemical reactions- relative signs of ΔH and ΔS.	3	
• Thermodynamic relations: Gibbs equations, Maxwell relations, the temperature dependence of G. Gibbs- Helmholtz equation.	2	
• Gibbs equations for non-equilibrium systems. Material equilibrium, phase equilibrium, Clapeyron equation, and Clausius-Clapeyron equation.	1	
• Conditions for equilibrium in a closed system, chemical potential of ideal gases, ideal-gas reaction equilibrium-derivation of the equilibrium constant, the temperature dependence of equilibrium constant-the Van't Hoff equation.	3	
Module-02: Electrochemistry-I	**12 hrs**	
• Electrochemical Cells: Derivation of Nernst equation–problems, chemical and concentration cells (with and without transference), liquid junction potential (LJP)–derivation, its determination, and elimination**.**	4	Power point presentations / Lectures/ Assignments
• **Types of reversible electrodes:** (i). Gas electrode, ex: Hydrogen electrode; (ii). Metal-Metal ion electrode, ex: Cu in $CuSO_4$, Zn in $ZnSO_4$; (iii). Metal-insoluble metal salt electrode, ex: calomel electrode, Ag-AgCl electrode; (iv). Redox electrodes, ex: Pt in	3	

Fe^{2+}/Fe^{3+}, Quinhydrone electrode; (v). Ion-selective electrodes, ex: H^+ selective-glass electrode.		
• Applications of EMF measurements: Solubility product, equilibrium constant measurements, determination of pH using glass electrode.	2	
• Applications of ion-selective electrodes in medicine (ex: blood electrolyte analysis).	1	
• Electrode polarization: its causes and elimination, concentration over potential, decomposition potential and its significance.	2	
Module-03: Quantum Chemistry- I	**12 hrs**	
• Introduction to quantum mechanics and Planck's quantum theory, Planck's equation (derivation not required).	1	
• Operators-operator algebra. Commutation of operators, linear operators. Complex functions. Hermitian operators. Operators ∇ and ∇^2.	2	
• Eigen functions and eigenvalues. Degeneracy. Linear combination of eigenfunctions of an operator. Well-behaved functions. Normalized and orthogonal functions.	2	
• Postulates of quantum mechanics. Physical interpretation of wave function. Observables and operators. Measurability of operators. Average values of observables.	2	Power point presentations / Lectures/ Assignments
• The time-dependent Schrodinger equation. Separation of variables and the time-independent Schrodinger equation.	1	
• Theorems of quantum mechanics: Real nature of the Eigen values of a Hermitian operator-significance. Orthogonal nature of the Eigen values of a Hermitian operator-significance of orthogonality. Expansion of function in terms of eigenvalues. Eigen functions of commuting operators-significance. Simultaneous measurement of properties and the uncertainty principle	4	
Module-04: Chemical Kinetics	**12 hrs**	
• Theories of reaction rates: Collision theory, steric factor, transition state theory, reaction coordinate, activated complex and the transition state, thermodynamic formulation of transition state theory, activation parameters and their significance, the Eyring equation, unimolecular reactions, and Lindemann's theory	4	
• Complex reactions: Opposing reactions, parallel reactions and consecutive reactions (all first-order type), chain reactions-general characteristics, steady-state treatment example: H_2-Br_2 reaction, derivation of rate law.	5	Power point presentations / Lectures/ Assignments
• Effect of structure on reactivity-linear free energy relationships, Hammett and Taft equations-substituent (σ and σ^*) and reaction constant (ρ and ρ^*) with examples.	3	
Module-05: Photochemistry	**12 hrs**	
• Electronic transitions in molecules, Franck Condon principle, electronically excited molecules- singlet and triplet states, radiative lifetimes of excited states.	3	
• Quantum yield and its determination, Derivation of fluorescence and phosphorescence quantum yields, E-type delayed fluorescence- evaluation of triplet energy splitting (ΔE_{ST}), P-type delayed fluorescence. The experimental study of photochemical reactions	4	

• Photophysical kinetics of unimolecular reactions, calculation of rate constants of various photophysical processes-problems, state diagrams	3	Power point presentations / Lectures/ Assignments
• Effect of light intensity on rates of photochemical reactions, photosensitization, quenching, Stern-Volmer equation.	1	
• Experimental set up of a photochemical reaction, introduction to fast reactions: Principle of flash photolysis.	1	

Learning Resources:

Module-01:

1. Peter Atkins and Julio de Paula, **Atkin's Physical Chemistry**, Oxford University press
2. Ira N. Levine, McGraw Hill, **Physical Chemistry**,
3. McQuarrie D. A. and. Simon J. D.**Physical Chemistry-A Molecular approach**, Viva Books Pvt. Ltd
4. McQuarrie D.A. and Simon J.D. **Molecular Thermodynamics**, University Science Books

Module-02:

5. Glasstone S. **Introduction to Electrochemistry**.
6. Bockris J. O. M. & Reddy A. K. N. Plenum, **Modern Electrochemistry**
7. Samuel Maron H. and Carl Prutton F. **Principles of physical chemistry**, Oxford& IBH

Module-03:

8. Ira N. Levine, Prentice Hall, **Quantum Chemistry**,
9. Chandra A. K. **Introduction to Quantum Chemistry**, Tata McGraw Hill
10. Prasad R.K. Quantum Chemistry, New Age Publisher, 2010.

Module-04:

11. Rajaraman and J. Kuriacose, **Kinetics and Mechanism of Chemical Transformations**, J McMillan
12. Laidler K.J. **Chemical Kinetics**, McGraw Hill
13. Espenson J. H. **Chemical Kinetics and Reaction Mechanisms**, McGraw Hill
14. Samuel H. Maron and Carl F. Prutton, **Principles of physical chemistry**, Oxford& IBH
15. Howard Maskill, **The Physical Basis of Organic Chemistry**, Oxford University Press (New York)
16. Isaacs N. S. **Physical Organic Chemistry**, ELBS

Module-05:

17. Rohtagi-Mukherji K. K. **Fundamentals of Photochemistry**, Wiley-Eastern
18. Turro N. J. **Molecular Photochemistry**, Benjamin
19. Kundall R. P. and Gilbert A. **Photochemistry**, Thomson Nelson
20. Gilbert A. and Baggott J. **Essentials of Molecular Photochemistry**, Blackwell Scientific Publications.
21. Coxon J. M. and Halton B. **Organic Photochemistry**, Cambridge University Press.
22. Cox A and Kemp T. J. **Introductory Photochemistry**, McGraw-Hill, London

ANALYTICAL TECHNIQUES AND SPECTROSCOPY-I

Credits: 4 **Semester: I**
Course Code: MOC26105 **No. of lecture hours: 60**

Objectives
- To acquire knowledge of chromatographic techniques.
- To gain knowledge of various spectroscopic techniques and their applications.

Course Outcomes
- Recognizes the importance of various chromatographic techniques
- Understands the magnetic properties of nuclei
- Distinguish and identify the various types of NMR spectra
- Analyses the approach of IR and Raman spectra for structural elucidation
- Identifies the electronic transitions in organic molecules

Course Content	Hours Allotted	Pedagogy
Module-01: Chromatography Techniques-I	**12 hrs**	
• Introduction to Chromatography and its classification. Gas Chromatography: Principle, Gas-Solid (GC, Adsorption) and Gas – Liquid (GLC, partition) chromatography	3	Power point presentations / Lectures/ Assignments
• Performing GC, separations & Instrumentation: Stationary phases, carrier gases, retention indices, detectors (TCD, FID, and NPD). Temperature selection and quantitative measurements. Applications of GC- Analysis of Gasoline.	4	
• High-Performance Liquid Chromatography (HPLC): Principles, stationary phases, equipment, normal phase (NPC) and reverse-phase chromatography (RPC), solvents, and columns for HPLC. Applications of HPLC. Analysis of paracetamol tablet.	3	
• Introduction to Ion Exchange Chromatography: Principles, cation and anion exchange resins, and applications.	2	
Module-02: NMR Spectroscopy-I	**12 hrs**	
• Magnetic properties of nuclei, principles of NMR. Instrumentation, CW, and FT NMR	3	Power point presentations / Lectures/ Assignments
• Equivalent and non-equivalent protons, enantiotopic and diastereotopic protons. Chemical shifts, factors affecting the chemical shifts- electronegativity and anisotropy, shielding and deshielding effects, signal integration	5	
• Spin-spin coupling vicinal-Karplus equation, geminal, long-range and virtual coupling, coupling constants, and factors affecting coupling constants	3	
• ^{1}H NMR of ethyl benzoate, 2-butanone, and 2-chloropropionic acid	1	
Module-03: NMR spectroscopy-II	**12 hrs**	
• Applications of ^{1}H NMR spectroscopy: Structure determination, reaction mechanisms (cyclic bromonium ion, electrophilic and nucleophilic substitutions, carbocations, and carbanions). *E, Z*-isomers, the conformation of cyclohexane and decalins, keto-enol	4	Power point

tautomerism, hydrogen bonding, proton exchange process, C-N rotation		presentations / Lectures/ Assignments
• First order and non-first order spectra e.g., AX, AX_2, AX_3, A_2X_3, AMX and AB	3	
• Simplification of complex spectra: increased field strength, deuterium exchange, Lanthanide shift reagents and double resonance techniques, discrimination of enantiomers by chiral NMR solvents	4	
• Nuclear Overhauser enhancement (NOE)	1	
Module-04: Vibrational & Raman spectroscopy	**12 hrs**	
• Introduction to molecular spectroscopy	1	
• **Vibrational Spectroscopy:** Vibrational energy levels of diatomic molecules, selection rules (derivation not required). Calculation of force constant from vibrational frequency	2	
• Anharmonic nature of vibrations. Fundamental bands, overtones and hot bands, Fermi resonance	1	
• Vibration-rotation spectra diatomic molecules. Vibrations of polyatomic molecules. Normal modes of vibration, the concept of group frequencies	2	Power point presentations / Lectures/ Assignments
• Characteristics of vibrational frequencies of functional groups; Stereochemical effects on the absorption pattern in carbonyl group, cis-trans isomerism and hydrogen bonding. Isotopic effect on group frequency.	3	
• **Raman Spectroscopy:** Quantum theory of Raman Effect, Vibrational Raman spectra, Stokes and anti- Stokes lines. Complementary nature of IR and Raman spectra	3	
Module-05: Electronic spectroscopy	**12 hrs**	
• Electronic spectra: Elementary energy levels of molecules. Types of transitions Selection rules for electronic spectra	2	
• Woodward-Fieser rules for chromophores: Conjugated dienes, trienes, unsaturated carbonyl compounds, benzene, and its derivatives, calculation of λ_{max}	5	Power point presentations / Lectures/ Assignments
• Solvent and structural influences on absorption maxima, stereochemical factors. *Cis-trans* isomers, and cross conjugation	3	
• Quantitative applications of electronic spectroscopy, the dissociation constant of a weak acid.	2	

Learning Resources:

Module-01:

1. Sane and Joshi, 1999, **Electro analytical Chemistry theory and applications,** Quest Publications.
2. Raymond PW Scott, **Techniques and practices of Chromatography,** Marcel Dekker, Inc. New York.
3. WMA Neissen & J V Greef, **Liquid Chromatography- Mass spectrometry Principles & Applications,** Marcel Dekker, Inc. New York.
4. Raymond PW Scott, 1988, **Introduction to analytical Gas Chromatography** (2^{nd}Ed.), Marcel Dekker, Inc. New York

Module-02, 03, 04, & 05:

5. Banwell and Mc Cash, 1966, **Fundamentals of Molecular Spectroscopy,** McGraw-Hill.
6. G.M. Barrow, 1962, **Introduction to Molecular Spectroscopy**, McGraw-Hill.
7. J.R. Dyer, 1965, Absorption **Spectroscopy of Organic Compounds,** Prentice-Hall, Englewood Cliffs, N.J.
8. R.M. Silverstein and F.X. Webster, 1998, **Spectroscopic identification of organic compounds,** (6th Ed), Wiley.
9. William Kemp, 2008, **Organic Spectroscopy** (3rd Ed.), Palgrave.
10. Pavia, 2004, **Introduction to organic spectroscopy** (3rd Ed.), Thomson
11. Jagmohan, 2010, Organic **Spectroscopy, Principles and Applications** (2nd Ed.), Narosa Publication House Pvt. Ltd.

GOOD LABORATORY PRACTICES

Credits: 1 **Semester: I**
Subject Code: MOC26151 **No. of hours/week: 2**

Learning Objectives

- To cultivate efficient working skills among the students to work in a chemistry laboratory. To create a trained workforce which can responsibly learn imbibe and explore verticals on structured knowledge safely.
- To make students aware of different chemicals and their properties being used in the chemistry laboratory.

Learning Outcomes

CO1: Know the design and implement safe working practices in chemistry laboratory.
CO2: Understand the safely handle different glass apparatus
CO3: Able to handle the chemicals and equipment safely and properly.
CO4: Gain Knowledge about the design working protocols related to various methods and instruments in chemistry laboratory.

S.No.	Name of the practical	Hours	Pedagogy
1.	Personal Protective Equipment (PPE) in Chemistry Laboratories	2	Power point presentations / Lectures/ Assignments/ Hands on Practice
2.	Design an illustrative chart exhibiting creativity at transaction of Do's and Don'ts instructions for working in a chemistry laboratory.	2	
3.	i). Carry out Classification and labeling of the given set of chemicals based upon Globally Harmonized System. ii). Carry out detailed survey of the Chemical Abstract Service (CAS) Registry Number and identify the given set of CAS RN and explain the different sections of CAS RN.	2	
4.	Carry out preparation of the indicative MSDS (Material Safety Data Sheet) of given set of chemicals as per Standard MSDS format.	2	
5.	Design an illustrative chart exhibiting creativity at transaction of Common Safety Symbols along with its description. Associate appropriate safety symbols with each of the given set of chemicals.	2	
6.	Chemistry Lab Standard Operations and Safety Measures.	2	
7.	Fire Hazards, types of fire & fire extinguishers, Draw and elucidate the National Fire Protection Association Hazard Labels. i. Identify and enlist the Incompatible Chemicals from a given set of chemicals available in the laboratory. ii. Carry out investigations on Labeling and storage of Chemical in laboratory.	2	
8.	i). Based on MSDS analysis, identify the required storage conditions for the given set of chemicals. ii). Describe procedure for the storage, maintenance and	2	

	handling of compressed gas cylinders. iii. Explore guidelines for the Storage of shelf chemicals and reagents.		
9.	i). Carry out a brief review of common pathways by which working Chemicals can enter the Body. ii). Carry out a detailed study of the Limits of Exposure of given Chemicals.	2	
10.	i) Classify the Hazard based on storage, handling, and disposal of chemicals. ii) Identification and describe handling protocols for Substances with Greater Hazardous Nature.	2	
11.	Carry out detailed investigations into procedural protocols for safe Disposal of Chemicals.	2	Power point presentations / Lectures/ Assignments/ Hands on Practice
12.	i). Carry out study on recommended Safety and Emergency Equipment essential for the safe practices in a Chemistry Laboratory. ii). Study the guidelines in the Event of a Chemical Accident or Spill.	2	
13.	i). Write detailed description on Fire Safety in the laboratory. ii. Carry out investigations of the data regarding Institute Safety Policies: Safety Audits / Inspections.	2	

Learning Resources

1. Skoog D.A., West D.M., Holler F.J., Stanley R.C., **Fundamentals of Analytical Chemistry**, 9th Edition, Cengage Learning.
2. Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (**2007**), **Vogel's Quantitative Chemical Analysis**, 6th Edition, Prentice Hall.
3. Furniss, B.S; Hannaford, A.J.; Smith, Peter W.G.; Tatchell, A.R; **Vogel's Textbook of Practical Organic Chemistry**, 5th Edition, Longman Scientific and Technical, Longman Group Ltd.
4. Garland, C.W.; Nibler, J.W.; Shoemaker, D.P. (**2003**), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.
5. https://iupac.org/
6. https://edu.rsc.org/resources/practical/experiments

INORGANIC CHEMISTRY PRACTICAL-I

Credits: 2 **Semester: I**
Course Code: MOC26152 **No. of hours/week: 4**

Objectives

- To synthesize inorganic complexes.
- To understand the techniques involved in the preparation of standard solutions, standardization, and estimations of metal ions.
- To analyze the metal ions gravimetrically.

Outcome

- The student will be able to synthesize various inorganic complexes, analyze qualitative (volumetric) and quantitative (gravimetric) estimations.

S.No.	Name of the Practical	Hours	Pedagogy
	Calibrations:		
1	Calibration of pipettes Calibration of burette	4 hrs	Hands on practice
	Preparation of complexes:		
2	Hexammine nickel (II) chloride.	4 hrs	Hands on practice
3	Tris(acetylacetonato)manganese	4 hrs	Hands on practice
4	Tris(ethylenediamine)nickel(II) thiosulphate	4 hrs	Hands on practice
5	Tetramminecopper(II) sulphate	4 hrs	Hands on practice
6	Ammonium tetrathiocyanatodiamminechromate(III)	4 hrs	Hands on practice
7	Iron (III) hexacyanoferrate (II)	4 hrs	Hands on practice
	EDTA-Titrimetric analysis:		
8	Estimation of Ni^{2+} by complexometry (direct titration method)	4 hrs	Hands on practice
9	Estimation of Cu^{2+} by complexometry (direct titration method)	4 hrs	Hands on practice
10	Estimation of Ca^{2+} by complexometry (substitution titration method)	4 hrs	Hands on practice
11	Estimation of Ni^{2+} by complexometry (back titration method)	4 hrs	Hands on practice
12	Estimation of Al^{3+} by complexometry (back titration method	4 hrs	Hands on practice
13	**One component gravimetric estimations** (**Use of sintered glass crucible**)**:** Estimation of Zn^{2+}	4 hrs	Hands on practice
14	Estimation of Ba^{2+}	4 hrs	Hands on practice

Learning Resources:

1. A. I. Vogel, **Textbook of Quantitative Inorganic Analysis** (3rd Ed.), ELBS 1969.
2. Jeffery et.al, **Vogel's textbook of Quantitative Inorganic analysis** (4th Ed.), ELBS 1988.
3. Jeffery et.al, **Vogel's textbook of Quantitative Inorganic analysis** (5th Ed.), ELBS 1989.
4. J. Mendham et.al, **Vogel's textbook of Quantitative Inorganic Analysis** (6th Ed.), Pearson education Ltd., 2000.
5. G. Marr and R. W. Rockett, 1972, **Practical Inorganic Chemistry**.
6. Mounir A. Malati, 1999, **Experimental Inorganic/Physical Chemistry–An Investigative integrated approach to Practical Project work**.

ORGANIC CHEMISTRY PRACTICAL-I

Credits: 2 **Semester: I**
Course Code: MOC26153 **No. of hours/week: 4**

Objectives

- To synthesize one-step organic compounds.
- To develop knowledge of greener methods of synthesis

Outcome:

- The student will develop the skill to carry out organic synthesis using conventional and greener methods.

S.No.	Name of the Practical	Hours	Pedagogy
1	Tetrahydrocarbazole	4 hrs	Hands on practice
2	7-Hydroxy-4-methyl coumarin	4 hrs	Hands on practice
3	*m*-Dinitrobenzene	4 hrs	Hands on practice
4	Hippuric acid	4 hrs	Hands on practice
5	Anthracene-maleic anhydride adducts,	4 hrs	Hands on practice
6	Phthalimide	4 hrs	Hands on practice
7	2,4-Dihydroxyacetophenone	4 hrs	Hands on practice
8	4-Chlorotoulene	4 hrs	Hands on practice
9	Methyl-4-nitro benzoate	4 hrs	Hands on practice
10	2,4,6-Tribromoaniline	4 hrs	Hands on practice
11	Azalactone	4 hrs	Hands on practice
12	Dibenzalactone	4 hrs	Hands on practice
13	1,3,5- Tribromobenzene	4 hrs	Hands on practice
14	Synthesis of organic compounds using microwave oven: 7-Hydroxy-4-methyl coumarin	4 hrs	Hands on practice
15	Anthracene-maleic anhydride adduct	4 hrs	Hands on practice
16	Dibenzalactone	4 hrs	Hands on practice

Learning Resources:

1. A.I.Vogel, 1989, **Textbook of practical organic chemistry** (5^{th} Ed.).

2. F. G. Mann and B.C. 1990, **Saunders, Textbook of practical organic chemistry** (5^{th} Ed.).

PHYSICAL CHEMISTRY PRACTICAL-I

Credits: 2 **Semester: I**
Course Code: MOC26154 **No. of hours/week: 4**

Objective

- To apply the knowledge of various electro analytical techniques for qualitative & quantitative reaction analysis

Outcome

- The student will learn about various electroanalytical techniques

S.No.	Name of the Practical	Hours Allotted	Pedagogy
	Colorimetry:		
1	Verification of Beer's law and calculation of molar absorption coefficient using $CuSO_4$ solution	2 Hrs	Hands on practice
2	Verification of Beer's law and calculation of molar absorption coefficient using $KMnO_4$ solution	2 Hrs	Hands on practice
	Conductometry:		
3	Titration of strong acid *vs* strong base	2 Hrs	Hands on practice
4	Titration of weak acid *vs* strong base	2 Hrs	Hands on practice
5	Determination of cell constant	2 Hrs	Hands on practice
6	Determination of dissociation constant of a weak acid	2 Hrs	Hands on practice
	Potentiometry:		
7	Titration of strong acid *vs* strong base	4 Hrs	Hands on practice
8	Titration of weak acid *vs* strong base	4 Hrs	Hands on practice
	Polarimetry:		
9	Determination of specific rotation of sucrose, glucose	4 Hrs	Hands on practice
10	Acid-catalyzed hydrolysis of sucrose (inversion of sucrose)	4 Hrs	Hands on practice
	pH metry:		
11	Calibration of a pH meter and measurement of pH of different solutions	2 Hrs	Hands on practice
12	Preparation of phosphate buffers.	2 Hrs	Hands on practice
	Chemical kinetics:		
13	Acid-catalyzed hydrolysis of methyl acetate	4 Hrs	Hands on practice
14	Peroxydisulphate - Iodide reaction (overall order)	4 Hrs	Hands on practice
	Distribution:		
15	Distribution of iodine between Cyclohexane and water	4 Hrs	Hands on practice
16	Distribution of I_2 between Cyclohexane and aq. KI solution - calculation of equilibrium constant	4 Hrs	Hands on practice

Learning Resources:

1. B.D. Khosla. **Textbook of senior practical physical chemistry**
2. Mounir A.Malati, 1999, **Experimental Inorganic/Physical Chemistry–An Investigative integrated approach to Practical Project work**.
3. J.B. Jadav **Advance Physical Practical Chemistry,** Krishna Publisher
4. A.K. Nad, B. Mahapatra and A. Ghoshal **Advance Course in Practical Chemistry.**

ANALYTICAL TECHNIQUES & SPECTROSCOPY PRACTICAL-I

Credits: 2 **Semester: I**
Subject Code: MOC26155 **No. of hours/week: 4**

Objectives

- To estimate and analyze various commercial samples and drugs
- To apply knowledge of Thin Layer Chromatography
- To interpret the structure of molecules using IR & NMR spectroscopy

Outcome

- The student will be able to analyze, develop and interpret the various qualitative and quantitative structural techniques.

S.No.	Name of the Practical	Hours allotted	Pedagogy
	Applied Analysis:		
1.	Estimation of acetic acid in commercial vinegar by acid base titration method	4Hrs	Hands on practice
2.	Estimation of available chlorine in bleaching powder by iodometry	4Hrs	Hands on practice
3.	Estimation of magnesium in talcum powder by complexometry	4Hrs	Hands on practice
	Thin Layer Chromatography:		
4.	Determination of suitable solvent system given 2 mixtures	2Hrs	Hands on practice
5.	Determination of purity of a given 2 samples	2Hrs	Hands on practice
6.	Identification of unknown organic compounds by comparing the R_f values of known standards	2Hrs	Hands on practice
7.	Determination of purity of compounds (2,4-Dihydroxyacetophenone, Tetrahydrocarbazole: Compounds from OC-I)	2Hrs	Hands on practice
8.	Monitoring the progress of chemical reaction for any of the two preparations (Compounds from OC-I)	2Hrs	Hands on practice
	Assay of drugs:		
9.	Aspirin by acid base back titration method	4Hrs	Hands on practice
	Spectral Analysis: Interpretation of spectra from NMR & IR data of the following representative compounds (minimum two examples each) with help of Molecular formula:		
10.	Saturated Hydrocarbons	2Hrs	Analysis of Data
11.	Unsaturated Hydrocarbons	2Hrs	Analysis of Data
12.	Aromatic Hydrocarbons	2Hrs	Analysis of Data
13.	Alcohol	2Hrs	Analysis of Data
14.	Aldehydes	2Hrs	Analysis of Data
15.	Ketones	2Hrs	Analysis of Data
16.	Carboxylic acids	2Hrs	Analysis of Data
17.	Amines	2Hrs	Analysis of Data
18.	Nitriles	2Hrs	Analysis of Data
19.	Esters	2Hrs	Hands on practice

Learning Resources:

1. R. Mukhopadhyay & P. Chatterjee, 2016, **Advanced practical chemistry,** NCBA books.
2. Gurdeep Raj, 2015, **Advanced Practical Inorganic Chemistry**, GOEL publishing house.
3. Ayodhya Singh, 2006, **Advanced experimental Inorganic Chemistry,** Campus books Int.
4. A. I. Vogel, 1989, **Textbook of practical organic chemistry** (5^{th} Ed.).
5. F. G. Mann and B.C. 1990, **Saunders, Textbook of practical organic chemistry** (5^{th} Ed.).

ARTIFICIAL INTELLIGENCE IN CHEMISTRY

Credits : 2 **Semester: II**
Course Code : MOC26201 **No. of lecture hours: 30**

Course Objective:

- To introduce the fundamental concepts of Artificial Intelligence, intelligent agents, types of AI, and the Turing Test.
- To understand AI problem-solving approaches and classical uninformed search techniques used to solve standard AI problems.
- To explain informed search techniques, heuristic methods, and game-playing strategies used in Artificial Intelligence
- To apply AI in Chemistry is an engaging and hands-on course that introduces chemistry students to the powerful world of AI as applied in various branches of chemistry.
- To use tools like Python, RD Kit, and Chemprop to predict molecular properties, design drugs, model reactions, and much more.

Course Outcomes:

CO1: Demonstrate an understanding of the fundamental concepts, types, and applications of Artificial Intelligence, including intelligent agents.

CO2: Formulate and solve Artificial Intelligence problems using appropriate problem representation techniques and uninformed search methods.

CO3: Apply informed search algorithms and game-playing strategies to analyse and solve Artificial Intelligence problems

CO4: Gain knowledge about AI in Chemistry and organic reaction

CO5: Familiar with tool and ethical issues in AI

Course Content	Hours Allotted	Pedagogy
Module 1: Introduction To AI	**06 Hrs**	
• Introduction to Artificial Intelligence: Definition, history and applications	1	Power point presentations / Lectures/ Assignments
• Intelligent Agents: Concept of agent, types of agents	2	
• Types of AI: Narrow AI, General AI, Strong AI vs Weak AI	2	
• Turing Test	1	
Module 2: AI Problem Solving And Search Techniques In AI	**06 Hrs**	
• AI Problem Solving: Introduction and problem representation, Production Systems and problem-solving steps	2	Lectures/ Assignments/ Power point presentations
• Examples of AI problems: Water Jug Problem, Missionaries and Cannibals	1	
• Search Algorithms: Introduction and classification	1	
• Uninformed Search Techniques: Breadth First Search, Depth First Search	1	
• Uniform Cost Search, Iterative Deepening Search	1	
Module 3: Search Techniques And Algorithms	**06 Hrs**	
• Informed Search Techniques: Best First Search, A* Search	2	

• Means–Ends Analysis	2	Interactive lectures / Assignments/ Power point presentations
• A* Search Algorithm: Basic working and evaluation	1	
• Game Playing: Minimax and Alpha–Beta pruning	2	
Module 4: AI Applications In Chemistry	**06 Hrs**	
• AI Applications in physical, organic, analytical and materials chemistry	2	Interactive lectures / Assignments/ Power point presentations
• Various applications of artificial intelligence in the field of chemistry	2	
• Reaction Prediction and Retro synthesis: Sequence-to-sequence models for chemical reactions - Transformer models (e.g., RXN for Chemistry)	2	
Module 5: Tools And Ethics In AI	**06 Hrs**	
• Tools and platforms (Python, RD Kit, scikit - learn, Tensor Flow, Chemprop)	**2**	Assignments / Lectures/ Power point presentations
• Materials Discovery with AI: High-through put screening - Predicting material properties	2	
• Ethical AI and Future Trends: Bias in chemical datasets	1	
• Interpretability and explainability - Future of AI in chemistry	1	

Learning Resources

1. Kumar, Ela. 2019. **Artificial Intelligence**. 1st Edition. I.K International Publishing House Pvt. Ltd. India: New Delhi
2. Russel J, Stuart. Norvig, Peter. 2015. **Artificial Intelligence, A Modern Approach**. 3rd Edition. Pearson Education. New Delhi: India.
3. Baum, Z. J., Yu, X., Ayala, P. Y., Zhao, Y., Watkins, S. P., & Zhou, Q. (2021). A **Survey of Artificial Intelligence in Chemistry**. *Journal of Chemical Information and Modeling*, 61(7), 3197- 3212. https://doi.org/10.1021/acs.jcim.1c00619 4. American Chemical Society. (2018).
4. **Artificial Intelligence in Chemistry: The Landscape of Drug Discovery. Chemical Abstracts Service**. https://www.cas.org/sites/default/files/documents/ai-chemistry-landscape.pdf
5. https://chemintelligence.com
6. Andrew White's deep learning for molecules & materials book, (https://dmol.pub)
7. MolSSI Education Resources, http://education.molssi.org/resources.html#programming
8. Greg Landrum's RDKit blog, (https://greglandrum.github.io/rdkit-blog/)
9. Esben Bjerrum's Cheminformania, (https://www.cheminformania.com)

INORGANIC CHEMISTRY-II

Credits: 4 **Semester: II**
Course Code: MOC26202 **No. of lecture hours: 60**

Objectives

- To impart knowledge of co-ordinate complexes, their reaction mechanisms and metal
- clusters
- To acquire the knowledge of special symmetry groups and assigns the same to the molecules.
- To understand the role of metal ions in biological systems.

Course Outcomes

- Perceives understanding about terms, term symbols, and microstates
- Enlight the knowledge about higher point groups
- Analyses the reaction pathways of complex formation
- Learn the structural patterns of metal clusters
- Validate the role of bioinorganic chemistry in everyday life

Course Content	Hours allotted	Pedagogy
Module-01: Bonding in metal complexes- II	**12 hrs**	
Free ion terms and Energy levels: Configurations, Terms, States and Microstates.	3	Power point presentations / Lectures/ Assignments
Formula for the calculation of Microstates p^n, d^n, configurations, L-S (Russel-Saunders) coupling scheme, j-j coupling scheme	3	
Determination of terms for p^1, p^2 and d^1, d^2 configurations of metal ions. Hole formalism, Energy ordering of terms (Hund's rules).	4	
Effect of weak cubic crystal fields on S, P, D and F terms- Introduction to Orgel diagrams, Orgel diagrams for d^1 and d^9 octahedra,d^2 and d^8 octahedra	2	
Module-02: Symmetry of molecules	**12 hrs**	
Classification and exercise on D_n, D_{nh}, D_{nd}, S_n (n=even)	5	Power point presentations / Lectures/ Assignments
Molecules of special Symmetry: Linear or Infinite groups $C_{\alpha v}$, $D_{\alpha h}$. Molecules containing multiple higher-order axis Td, O_h, I_h		
Exercises on point groups, descent and ascent in symmetry of molecules with substitution	4	
Symmetry criteria for optical activity, symmetry restrictions on dipole moment	3	
Module-03: Reaction Mechanism-II	**12 hrs**	
Ligand substitution reactions in square planar complexes: Mechanism of substitution in square planar complexes, trans-effect, Grinberg's polarization theory and π - bonding theory, applications of Trans-effect in the synthesis of Pt (II) complexes	5	Power point presentations / Lectures/ Assignments
Electron transfer reactions (or Oxidation-Reduction) in Coordination compounds: Mechanism of One-electron transfer reactions: Inner sphere electron transfer and Outer sphere electron transfer, Cross reactions and Marcus Hush theory	5	
Nature of bridging ligands. Distinguish between, outer sphere & inner sphere electron transfer reaction mechanism	2	

Module-04: Metal clusters	**12 hrs**	
Polyhedral skeletal electron pair theory and total electron count theory, Wade's rules and polyhedral geometries of carbonyl clusters	3	Power point presentations / Lectures/ Assignments
Carbonyl clusters: Factors favouring metal-metal bonding	1	
Classification of clusters: Low nuclearity clusters: M_3 and M_4 clusters. Structural patterns in $M_3(CO)_{12}$ [M=Fe, Ru, Os] and $M_4(CO)_{12}$ [M=Co, Rh, Ir] clusters. Relative stability of bridging and nonbridging structures	3	
High Nuclearity clusters: M_5, M_6, M_7, M_8 and M_{10} clusters. Capping rule.	1	
Structural patterns in $[Os_6(CO)_{18}]^{2-}$, $[Os_7(CO)_{21}]$, $[Rh_7(CO)_{16}]^{3-}$, $[Os_8(CO)_{22}]^{2-}$, $[Os_{10}C(CO)_{24}]^{2-}$ and $[Ni_5(CO)_{12}]^{2-}$	2	
Introduction to metal Halide clusters: Major structural types in dinuclear Metal-Metal system: Face sharing Bioctahedra, Edge sharing Bioctahedra, Tetragonal prismatic and Trigonal antiprismatic	2	
Structure and bonding in $[Re_2Cl_8]^{2-}$		
Module-05: Bio Coordination Chemistry	**12 hrs**	
Oxygen transport proteins: Haemerythrin (Hr) and Haemocyanin (Hc): Introduction-structure of active sites with oxygen and without oxygen.	4	Power point presentations / Lectures/ Assignments
Oxygen binding, geometric, electronic, and magnetic aspects of Hemerythrin and Hemocyanin	2	
Electron transfer proteins: Introduction, Ferredoxins- [1Fe-0S], [2Fe-2S], Rieske proteins, Cupredoxins- comparison of Type-I, Type-II and Type-III proteins, role of each structural feature in determining the spectroscopic and functional properties of cupredoxins- Geometry, Axial ligands, Equitorial histidines, backbone carbonyl oxygen, structures of plastocyanin, azurin, stellacyanin and nitrosocyanin.	6	

Learning Resources:

Module-01:

1. J.E.Huheey, K.A.Keiter and R.L.Keiter, 1993, **Inorganic Chemistry** (4th Ed.), Harper Cottens College Publications.

Module-02:

2. K.Veera Reddy 2009, **Symmetry and Spectroscopy of Molecules** New Age International Publishers.
3. Mark Ladd, 2000 **Symmetry and Group theory in Chemistry**, Marwood Publishers, London.
4. Robert L.Carter, 1998 **Molecular Symmetry and Group Theory**, John Wiley & Son

Module-03:

5. K.Veera Reddy, 2005. **Metal ions in Reaction Mechanisms** (1st Ed.), Golgotia Publications (P) Ltd.
6. Richard A Henderson, 1993, **Mechanisms of Reactions in Transition Metal Sites,** Oxford Science Publications, London.

7. F.Basolo and R.G.Pearson, 1967, **Inorganic Reaction Mechanisms** (2nd Ed.), Wiley, New York.

Module-04:

8. F.A.Cotton, G.Wilkinson, C.A.Murillo and M.Bochmann, 1999, **Advanced Inorganic Chemistry** (6th Edition), Wiley Interscience, New York.
9. G.L.Eichorn, 1982, **Inorganic Biochemistry** (Vol. 1)., Elsevier
10. Keith F. Purcell and John C. Kotz, 1977, **Inorganic Chemistry**, Holt-Saunders International Editions, London.

Module-05:

11. I.Bertini, H.B.Gray, S.J.Lippard and SJ.Valentine, 1998, **Bioinorganic Chemistry** (1st Ed.), Viva Low- Priced Student Edition, New Delhi.
12. W.Kain and B.Schwederski, 1999, **Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life**, John Wiley and Sons, NY.
13. Keith F.Purcell and John C.Kotz, 1977, **Inorganic Chemistry**, Holt-Saunders International Editions, London.

ORGANIC CHEMISTRY-II

(Organic Reaction Mechanism, Stereochemistry, Pericyclic Reactions & Heterocyclic Chemistry)

Credits: 4 **Semester: II**

Course Code: MOC26203 **No. of lecture hours: 60**

Objectives

- To understand the conformational analysis of the cyclic system.
- To understand the mechanisms in organic reactions involving aromatic systems.
- To acquire knowledge of pericyclic reactions.
- To understand the structure of heterocyclic compounds.

Course Outcomes

CO1: Develop an understanding of organic reaction mechanisms
CO2: Perceives the concept of conformational analysis
CO3: Appreciates the fundamentals of pericyclic reactions
CO4: Apply the theories of pericyclic to molecular reactions
CO5: Gains knowledge in the basics of hetero cyclic compounds

Course Content	Hours allotted	Pedagogy
Module-01: Reaction Mechanism-II	**12 hrs**	
• Nucleophilic Aromatic substitution: Aromatic Nucleophilic substitution: S_N1 (Ar), S_N2 (Ar), and benzyne mechanisms. Definition and types of ambident nucleophiles	3	Power point presentations / Lectures/ Assignments
• Neighboring group participation: Criteria for determining the participation of the neighboring group. Enhanced reaction rates, retention of configuration, isotopic labeling, and cyclic intermediates	2	
• Neighboring group participation involving halogens, oxygen, nitrogen, aryl, cycloalkyl groups, σ and π- bonds, and non-classical carbocations	2	
• Electrophilic substitution saturated carbon and single electron transfer reactions. Mechanism of aliphatic electrophilic substitution SE_1, SE_2, and SE^i. SET mechanism	5	
Module-02: Conformational Analysis (Cyclic Systems)	**12 hrs**	
• Study of conformations of cyclohexane, mono-, di-substituted cyclohexane.	4	Power point presentations / Lectures/ Assignments
• Cyclohexene, cyclohexanone (2-alkyl and 3-alkyl ketone effect), and 2-halo cyclohexanones	2	
• Stereochemistry of decalins, bicyclo-(3,3,0)-octane and hydrindanes	1	
• Conformational structures of piperidine, N-methylpiperidine, D-Glucose (Pyranose and Furanose)	1	
• Conformational effects on the stability and reactivity of diastereomers in cyclic molecules - steric and stereo electronic factors – examples	2	
• Factors governing the reactivity of axial and equatorial substituents in cyclohexane	1	
• Stereochemistry of addition to the carbonyl group of a rigid cyclohexanone ring	1	

Module-03: Pericyclic Reactions-I	**12 hrs**	
• Introduction, Classification of Pericyclic reactions, 4n, 4n+2 systems, and examples. Molecular orbitals: ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene, allyl cation, allyl radical, pentadienyl cation, pentadienyl radical	3	Power point presentations / Lectures/ Assignments
• Electrocyclic reactions: con rotation and dis rotation. Electrocyclic closure and opening in 4n and 4n+2 systems.	2	
• Cycloaddition reactions: suprafacial and antara facial additions. 4n and 4n+2 cycloadditions. Stereochemical aspects in supra-supra, supra-antara, antara-supra and antara-antara 4n and 4n+2 cycloadditions,	3	
• Sigmatropic reactions [i, j] shifts- suprafacial and antarafacial shifts,	1	
• Introduction to Aromatic Transition state Theory: Concept, Woodward-Hoffman se1ection rules for electrocyclic reactions, cycloaddition and sigmatropic reactions based on ATS aromatic transition state (Huckel-Mobius) approach	3	
Module-04: Pericyclic Reactions-II	**12 hrs**	
Theories involved in understanding pericyclic reactions:		
• Frontier Molecular Orbital Theory: Concept, Woodward- Hoffman selection rules for electrocyclic, cycloaddition, and sigmatropic reactions based on FMO approach	4	Power point presentations / Lectures/ Assignments
• Diels Alder reaction *(endo, exo)*- stereoselectivity	3	
• Cope, Aza-Cope and Claisen rearrangement reactions	1	
• Conservation of Molecular Orbitals Theory: Construction of correlation diagram for 4n & 4n+2 electrocyclic reactions and cycloaddition ($\pi^2s+\pi^2s$ & $\pi^4s+\pi^2s$) systems	4	
Module-05: Heterocyclic chemistry	**12 hrs**	
• Nomenclature of heterocyclic systems based on ring size, number and nature of hetero atoms	4	Power point presentations / Lectures/ Assignments
• Synthesis and reactivity of indole, benzofuran	3	
• Synthesis and reactivity of benzothiophene, quinoline, isoquinoline, coumarin, chromone	5	

Learning Resources:

Module 01:

1. Jerry March 1992, **Advanced Organic Chemistry**(5th Ed.), Wiley-India student edition
2. S. Mukerjee,2007, **Mechanism and Structure in Organic Chemistry** (3rd Ed.), MacMillan Publishers India Limited
3. I. L. Finar, 1963, **Organic chemistry** (4th Ed.), Vol. I and II, Longmans
4. D. H. R. Barton and W. D. Ollis, 1978, **Comprehensive Organic Chemistry**, Vol.5.

Module -02:

5. Ernest L Eliel, Samuel H.Wilen, 2008, **Stereochemistry of Carbon compounds**, John Wiley & Sons INC.
6. D. Nasipuri, 2006, **Stereochemistry of Organic Compounds- Principles and Applications** (2nd Ed.), New Age International publishers.
7. P S Kalsi, 2010, **Stereochemistry: Conformation & Mechanism** (7th Ed.), New Age International publishers

Module 03 & 04:

8. Woodward and Hoffmann, 1971, **Conservation of Orbital Symmetry Available** as e-book.
9. Gilchrist and Storr, 1979, **Organic Reactions and Orbital Symmetry**, Cambridge University Press.
10. J.Singh, 2006, **Photochemistry and Pericyclic Reactions** (2nd Ed.), New Age International publishers.
11. Lehr and Merchand, 1972. **Pericyclic Reactions—a problem solving approaches**, Academic Press: New York.

Module -05:

12. Gilchrist, T. 1987. **Heterocyclic Chemistry.** Pitmann Publishing Ltd.
13. Bansal, R. K. 2005. **Heterocyclic Chemistry**. 4th Edition. New Delhi: New Age International Pvt. Ltd.
14. Joule J.A. and Mills, K. 2004. **Heterocyclic Chemistry**. 4th Edition. Blackwell Publishers.
15. Joule J.A. and Smith. 2010. **Heterocyclic Chemistry**. 5th Edition. ELBS.
16. Acheson. R. M. 1967. **An Introduction to the Chemistry of Heterocyclic Compounds.** 2nd Edition. Wiley & Sons.
17. Gupta R R. Kumar, M. and Gupta V. 2005. Vol-I and Vol-II. **Heterocyclic Chemistry**. 1st Indian Edition Springer publications.

PHYSICAL CHEMISTRY-II

Credits: 4 **Semester: II**
Course Code: MOC26204 **No. of lecture hours: 60**

Objectives

- To understand the thermodynamic properties of reactions.
- To study the nature of electrochemical cells and their applications
- To impart knowledge about the subatomic particles of matter.
- To acquire the knowledge of energy calculation at the atomic level.
- To understand the concepts of solid state chemistry.

Course Outcomes

CO1:	To provide knowledge related to thermodynamics in terms of chemical potential and phase equilibria
CO2:	To understand theories and principles of electroanalytical techniques in terms amperometry, voltammetry and types of currents
CO3:	Apply the knowledge of quantum chemistry and to analyze and Evaluate problems of quantum chemistry
CO4:	Analyze and Evaluate problems of quantum chemistry, spectroscopy to the different areas of chemistry
CO5:	Applications of solid state material in terms of band theory, electrical and magnetic optical properties of solids and knowledge of super conductors and their applications.

Course Content	Hours allotted	Pedagogy
Module-01: Thermodynamics-II	**12 hrs**	
• Solutions: Specifying the Solution composition, partial molar properties-significance, relation between solution volume and partial molar volume.	3	Power point presentations / Lectures/ Assignments
• The chemical potential, variation of chemical potential with T and P, Gibbs-Duhem equation-derivation and significance	1	
• Ideal solutions: Thermodynamic properties of ideal solutions, mixing quantities, vapour pressure-Raoult's law. Thermodynamic properties of ideally dilute solutions, vapour pressure- Henry's law	3	
• Non ideal solutions: Activities and activity coefficients, standard-state conventions for non-ideal solutions, determination of activity coefficients from vapour pressure measurements, activity coefficients of nonvolatile solutes using Gibbs-Duhem equation	4	
• Multi component phase equilibrium: Vapour pressure lowering, freezing point depression and boiling point elevation	1	
Module-02: Electrochemistry-II	**12 hrs**	
• Electrode polarization: its causes and elimination, concentration overpotential.	2	Power point presentations
• Decomposition potential and its significance.		
• Types and Classification of Electroanalytical Methods.	1	
• Amperometric titrations: Principle, instrumentation and applications of amperometric titrations, determination of SO_4^{2-}, metal ions viz., Mg^{2+}, Zn^{2+}.	3	

• Cyclic voltammetry: Principle, instrumentation, reversible and irreversible cyclic voltammograms, Application: Cyclic voltammetric study of insecticide parathion	3	/ Lectures/ Assignments
• D.C Polarography: Two and Three electrode assemblies. Dropping mercury electrode, instrumentation	1	
• Types of Currents: Residual, Migration, Limiting. Types of limiting Currents: Adsorption, Diffusion, Kinetic	2	
Module-03: Quantum chemistry-II	**12 hrs**	
• Particle in a box-one dimensional and three dimensional	2	
• Plots of ψ and ψ^2-discussion. Degeneracy of energy levels. Comparison of classical and quantum mechanical particles	2	
• Calculations using wave functions of the particle in a box-orthogonality, measurability of energy, position and momentum, average values and probabilities	2	Power point presentations / Lectures/ Assignments
• Application to the spectra of conjugated molecules	1	
• Schrodinger equation for the hydrogen atom- separation into three equations.	3	
• Hydrogen like wave functions. Radial and angular functions. Quantum numbers n, l and m their importance.		
• The radial distribution functions. Hydrogen-like orbitals and their representation. Polar plots, contour pots, and boundary diagrams	2	
Module-04: Quantum chemistry-III	**12 hrs**	
• Many electron systems. Approximate methods. The variation method-variation theorem and its proof. Trial variation function and variation integral.	3	
• Examples of variational calculations. Particle in a box. Construction of trial functions by the method of linear combinations. Variation parameters. Secular equations and secular determinant.	2	Power point presentations / Lectures/ Assignments
• Bonding in molecules: Molecular orbital theory-basic ideas. Construction of MOs by LCAO, H_2^+ ion. The variational integral for H_2^+ ion (Detailed calculation of Wave functions and energies for the bonding and antibonding MO's not required). The physical picture of bonding and antibonding wave functions. Energy diagram	3	
• Multi-electron atoms. The Hartree-Fock self-consistent field method. Basis functions. Slater-type orbitals (STOs).	2	
• Concept of hybridization – sp, sp2 , and sp3 hybrid orbitals.	2	
Module-05: Solid-state chemistry	**12 hrs**	
• Electrical and Magnetic properties of solids- classification of electrical and magnetic materials, Magnetic susceptibility	2	
• Electronic properties of metals, insulators, and semiconductors: Electronic structure of solids, Band theory- band structure of metals, insulators, and semiconductors	3	
• Photoconductivity and photovoltaic effect-*p*-*n* junctions	2	Power point presentations / Lectures/ Assignments
• Superconductivity*:* Occurrence of superconductivity, destruction of superconductivity by magnetic fields-Meisner effect, theories of superconductivity- BCS theory	3	
• High-temperature superconductors*:* Structure of defect perovskites. High Tc superconductivity in cuprates, phase diagram of Y-Ba-Cu-O system, the crystal structure of YBa2Cu3O7-x.	2	

Learning Resources:

Module 01:

1. Peter Atkins and Julio de Paula. **Atkin's Physical Chemistry**, Oxford University press
2. Ira N. Levine. **Physical Chemistry**, McGraw Hill
3. D. A. McQuarrie and J. D. Simon. **Physical Chemistry-A Molecular approach**, Viva Books Pvt. Ltd
4. D. A. McQuarrie and J. D. Simon. **Molecular Thermodynamics**, University Science Books

Module 02:

5. Heyrovsky, 1966. **Principles of Polarography,** Publishing House of the Czechoslovak Academy of Sciences,
6. Kapoor. R. C. Agarwal B. S. 1991. **Principles of Polarography,** Wiley.
7. Charlot C.1962. **Modern Electro analytical methods,** Elsevier Company.

Module 03 & 04:

8. Ira N. Levine. **Quantum Chemistry**, Prentice Hall
9. A. K. Chandra. **Introduction to Quantum Chemistry**, Tata McGraw Hill

Module 05:

10. Leonid V. Azaroff. **Introduction to Solids**, Tata McGraw Hill
11. Chakrabarthy. D. K. **Solid state Chemistry**, New Age International
12. West. A. R. **Solid state Chemistry and its applications**, Plenum.
13. **Keer. H. V.** Principles of the Solid State**, New Age International**

ANALYTICAL TECHNIQUES AND SPECTROSCOPY-II

Credits: 4 **Semester: II**

Course Code: MOC26205 **No. of lecture hours: 60**

Objectives

- To acquire knowledge of hyphenated techniques.
- To gain knowledge of various spectroscopic techniques and their applications.

Course Outcomes

CO1: Summarizes the concepts of hyphenated techniques

CO2: Acquires knowledge about various types of NMR spectra and ESR Spectroscopy

CO3: Gain knowledge about mass spectrometry

CO4: Analyze the chemical structure using mass fragmentation

CO5: Identifies the varied techniques in the synthesis of nanomaterials.

Course Content	Hours allotted	Pedagogy
Module-01: Chromatography Techniques-II	**12 hrs**	
• **GC-MS:** Principle, instrumentation; interfaces, jet separators, mass analyzer, mass chromatogram with an example, applications	3	Power point presentations / Lectures/ Assignments
• **GC-FT-IR**: Instrumentation, principles and applications	3	
• **LC-MS**: Instrumentation, principles, interfaces and applications	3	
• **ICP-MS**: Instrumentation, principles, quantitative analysis and applications	3	
Module-02: NMR Spectroscopy-III & ESR Spectroscopy	**12 hrs**	
• Study of aromaticity and fluxional molecules (eg.$[C_8H_8Ru(CO)_3]$, NMR of paramagnetic compounds: acetylacetone complexes	2	
• ^{19}F NMR spectroscopy: ^{19}F chemical shifts, coupling constants. Applications of ^{19}F NMR involving coupling with ^{19}F, ^{1}H and ^{31}P: 2,2,2-trifluoro ethanol, 1,2-dichloro-1,1-difluoro ethane, 5-bromo-1,2,3-trifluoro benzene, BrF_5, SF_4, PF_5, ClF_3, IF_5	3	Power point presentations / Lectures/ Assignments
• Introduction, principle, instrumentation, selection rules	3	
• Hyperfine and super hyperfine Coupling	2	
• Significance of ‘g’ factor	1	
• Study of free radicals	1	
Module-03: Mass spectrometry-I	**12 hrs**	
• Origin of mass spectrum, principles of EI mass spectrometer	2	
• Principle of EI, CI, ESI, Fast Atom Bombardment (FAB), and Matrix Assisted Laser Desorption Ionization (MALDI) methods. High resolution mass spectrometry	5	Power point presentations / Lectures/ Assignments
• Types of fragments: odd electron and even electron containing neutral and charged species (even electron rule), Nitrogen rule, isotopic peaks, metastable ion peaks, double bond equivalence, and determination of molecular formula,	5	
Module-04: Mass spectrometry-II	**12 hrs**	
• Fragmentation pattern of organic compounds: Alkanes, alkenes, alkynes, aromatic& aralkyl compounds, alkyl halides, alcohols,	9	

phenols, ethers, carbonyl compounds, carboxylic acids and its derivatives, amines, nitro and nitroso compounds, nitriles, (β-cleavage, McLafferty rearrangement, retro Diels–Alder fragmentation, ortho effect, dehydration, dehydrohalogenation, decarboxylation and elimination of NO).		Power point presentations / Lectures/ Assignments
• Fragmentation of cycloalkanols, cycloalkanones and cyclo alkyl amines	3	
Module-05: Nano chemistry	**12 hrs**	
• Introduction, definition of a nanosystem, dimensionality and size dependent phenomena, Surface to volume ratio, Fraction of surface atoms, Surface energy	3	
• Preparation of nanoparticles– Bottom-up approach, Top-down approach, chemical vapour deposition method, Thermolysis method, Pulsed laser method	3	Power point presentations / Lectures/ Assignments
• Carbon-based nano materials (buckyballs, nanotubes, graphene),	2	
• Characterisation of Nanomaterials: UV-Visible spectroscopy, SEM, TEM, (principles only)	3	
• Applications of nanomaterials in medicine	1	

Learning Resources:

Module-01:

1. Sane and Joshi, 1999, **Electro analytical Chemistry theory and applications,** Quest Publications.
2. Raymond PW Scott, **Techniques and practices of Chromatography,** Marcel Dekker, Inc. New York.
3. WMA Neissen& J V Greef, **Liquid Chromatography-Mass spectrometry Principles & Applications,** Marcel Dekker, Inc. New York.
4. Raymond PW Scott, 1988, **Introduction to Analytical Gas Chromatography** (2^{nd} Ed.), Marcel Dekker, Inc. New York

Module-02:

5. Jag Mohan, 2008, **Organic Spectroscopy-Principles applications** (2^{nd} Ed.), Narosa publications.
6. William Kemp, 2008, **Organic Spectroscopy** (3^{rd} Ed.), Palgrave.
7. R.M. Silverstein and F.X. Webster,1998, **Spectroscopic identification of organic compounds,** (6^{th}Ed), Wiley.
8. William Kemp,1988, **NMR-A multinuclear introduction** (3^{rd} Ed.), MacMillan.
9. W. Dolbier, 2009, **Guide to Fluorine NMR for organic chemist** (1^{st}Ed.), Wiley.

Module-03 & 04:

10. A. H. Beckett and J.B. Stenlake, 1988, **Practical Pharmaceutical Chemistry** (4^{th} Ed.), WCIR, London
11. Robert Alexander Walker Johnstone, 1996, **Mass Spectrometry for Chemists and Biochemists** (2^{nd} Ed.), Cambridge University Press.
12. Pavia, 2004, **Introduction to organic spectroscopy** (3^{rd} Ed.), Thomson
13. R.M. Silverstein and F.X. Webster, 1998, **Spectroscopic identification of organic compounds,** (6^{th}Ed), Wiley.

Module-05:

14. Pradeep T. 2007, **Nano: the Essentials**. Tata McGraw Hill.
15. Varghes T and Balakrishna K. M. 2012, **Nanotechnology,** Atlantic publishers.
16. Pradeep T.2012. **Textbook of Nano Science and Nanotechnology,** Tata McGraw Hill

INTERDISCIPLINARY COURSE
CHEMISTRY IN DAILY LIFE

Credits: 2 **Semester: II**
Course Code: MOC 26206 **No. of lecture hours: 30**

Objectives

- To acquire knowledge of chemistry in daily life.

Course Outcomes

CO1: Analyzes the components of milk products.
CO2: Acquire knowledge about analysis of food and beverages.
CO3: Gain knowledge about factors causing environmental pollution
CO4: Analyzes the causes and identifies remedies for air pollution.
CO5: Understands the causes and consequences of water pollution.

Course Content	Hours allotted	Pedagogy
Module 01: Chemistry in dairy and food industries	**6 hrs**	
• Composition of milk and milk products.	1	Power point presentations / Lectures/ Assignments
• Analysis of fat content, minerals in milk and butter.	2	
• Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose and sodium cyclamate.	2	
• Estimation of added water in milk.	1	
Module 02: Chemical analysis of food products	**6 hrs**	
• Beverages: Analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy, estimation of methyl alcohol in alcoholic beverages.	2	Power point presentations / Lectures/ Assignments
• Flavours: Vanillin, alkyl esters (fruit flavours) and monosodium glutamate	1	
• Artificial food colorants: Coal tar dyes and non-permitted colours and metallic salts.	2	
• Analysis of pesticide residues in food	1	
Module 03: Environmental pollution	**6 hrs**	Power point presentations / Lectures/ Assignments
• Classification of environmental Pollution, Types of pollutants,	2	
Causes and effects of environmental Pollution	1	
Measures for environmental restoration	1	
Laws of environmental Pollution	2	
Module 04: Chemistry in air pollution	**6 hrs**	Power point presentations / Lectures/ Assignments
• Air pollution- Greenhouse gases and acid rain. Ozone hole and CFC's. Photochemical smog and PAN. Catalytic converters for mobile sources. Bhopal gas tragedy.	3	
• Prevention and control of air pollution.	3	
Module 05: Chemistry in water pollution	**6 hrs**	Power point presentations / Lectures/
• Hydrologic cycle, sources, criteria and standards of water quality-safe drinking water. Public health significance and	2	

measurement of water quality parameters - (Colour, turbidity, total solids, acidity, alkalinity, hardness, BOD and COD).		Assignments
• Water purification for drinking and industrial purposes. Toxic chemicals in the environment.	2	
• Solid pollutants- treatment and disposal. Treatment of industrial liquid waste. Sewage and industrial effluent treatment.	2	

Learning Resources:

1. B. K. Sharma. 1998 **Introduction to Industrial Chemistry**. Goel Publishing, Meerut
2. Ashutoshkar. 2005. **Medicinal Chemistry.** 3rd Edition. New Delhi: New Age International Publishers.
3. Marcel Dekker. **Drugs and Pharamaceutical Sciences Series**, Vol. II, INC, New York
4. H.E.Cox and Pearson. 1962. **Chemical Analysis of Foods**. Chemical Publishing House.
5. N. Shakuntala Mani and S. Swamy. 1998. **Foods: Facts and Principles**. 4thEdition. New Age International
6. P J Atkins and J. de Paula. 2002. **Physical Chemistry**. 7th Edition. Oxford University Press.
7. Swami Nathan and Goswamy. 2001. **Handbook on Fertilizer Technology**. 6th Edition, FAI.
8. Finar, I.L. 2009. **Textbook of Organic Chemistry**. Vol II. 5th Edition. Pearson Publications.
9. J. R. Fired. **Polymer Science and Technology**. Prentice Hal

INORGANIC CHEMISTRY PRACTICAL-II

Credits: 2 **Semester: II**
Course Code: MOC26251 **No. of hours/week: 4**

Objectives:

- To analyze the metal ions gravimetrically.
- Separation and analysis of mixture of complexes volumetrically and gravimetrically.

Course Outcomes:

- The student will learn to perform gravimetric and volumetric analysis of the inorganic complexes.

S.No.	Name of the practical	Hours	Pedagogy
1.	**Preparation of complexes**: Mercurytetrathiocyanatocobaltate (II)	4 hrs	Hands on practice
2.	Pentaammine(chloro)cobalt (III) chloride	4 hrs	Hands on practice
3.	Potassium dioxalatocuprate(II) dehydrate	4 hrs	Hands on practice
4.	Iron (II) hexacyanoferrate (III)	4 hrs	Hands on practice
5.	**Applied titrimetric analysis:** Determination of calcium in calcium tablets	4 hrs	Hands on practice
6.	Analysis of iron and calcium in cement	4 hrs	Hands on practice
7.	**Analysis of Two component mixtures**: Separation of Ni^{2+} and Cu^{2+} in a mixture & estimation of Ni^{2+} (gravimetric) and Cu^{2+} (volumetric)	4 hrs 4 hrs	Hands on practice
8.	Separation of Al^{3+} and Fe^{3+} in a mixture & estimation of Al^{3+} (gravimetric) and Fe^{3+} (volumetric)	4 hrs 4 hrs	Hands on practice
9.	Separation of Ag^{+} and Ca^{2+} in a mixture& estimation of Ag^{+} (gravimetric) and Ca^{2+} (volumetric)	4 hrs 4 hrs	Hands on practice
10.	**Analysis of three component mixtures**: Separation of (Ni^{2+} and Cu^{2+}) from Mg^{2+} in the given mixture & estimation of Mg^{2+} (Gravimetric)	4 hrs	Hands on practice
11.	Separation of (Fe^{2+} and Ni^{2+}) from Zn^{2+} in the given mixture & estimation of Zn^{2+} (Gravimetric)	4 hrs	Hands on practice

Learning Resources:

1. Jeffery et.al, 1988, **Vogel's text book of Quantitative Inorganic analysis** (4^{th} Ed.), ELBS.
2. Jeffery et.al, 1989, **Vogel's text book of Quantitative Inorganic analysis** (5^{th} Ed.), ELBS
3. J. Mendham et.al, 2000, **Vogel's text book of Quantitative Inorganic Analysis** (6^{th} Ed.), Pearson education Ltd.

ORGANIC CHEMISTRY PRACTICAL-II

Credits: 2 **Semester: II**
Course Code: MOC26252 **No. of hours/week: 4**

Objectives

- To identify the given organic compound and assign its functional group qualitatively.
- To separate an organic mixture and apply systematic functional group analysis.

Outcome

- The student will be able to separate the mixture and analyze the organic functional groups present.

S.No.	Name of the practical	Allotted Hours	Pedagogy
1.	**Identification of organic compounds systematic qualitative analysis**: Physical data BP / MP, Ignition test, solubility classification, Extra elements-N, S & Halogens, (Lassaigne's sodium fusion test)	4 hrs	Hands on practice
2.	Functional groups tests, Preparation of crystalline derivatives and determination of their mp's for at least 0**4** compounds belonging to strong acid, weak acid, neutral, bases, carbohydrates & hydrocarbons.	16 hrs	Hands on practice
3.	**Separation of two-component mixtures by chemical methods and their identification by chemical reactions** Separation by using solvent ether, dil. hydrochloric acid, 5 % aqueous sodium bicarbonate and sodium hydroxide solutions.	8 hrs	Hands on practice
4.	Checking the purity of the two components by TLC, identification of the compounds by a systematic study of the physical characteristics (mp/ bp), extra elements (nitrogen, halogens and sulfur), solubility, functional groups, preparation of crystalline derivatives.	4 hrs	Hands on practice
5.	Separation and analysis of a minimum of **05 binary mixtures** by these procedures. Following combinations can be given: Strong acid + neutral including hydrocarbons, Strong acid + weak acid, Weak acid + neutrals include hydrocarbon, Base+ hydrocarbon, Carbohydrate + weak acid, Carbohydrate + strong acid (other than *p*-nitrobenzoic acid) Separation of neutral components of binary mixture using column chromatography	4 hrs 4 hrs 4 hrs 4 hrs	Hands on practice

	Synthesis of the following compounds:		
6.	Synthesis of ethyl benzoate from benzoic acid, separation of product by separation techniques	4 hrs	Hands on practice
7.	Benzanilide from benzophenone (Beckmann rearrangement)	4 hrs	Hands on practice
8.	Synthesis of silver nanoparticles	4 hrs	Hands on practice

Learning Resources:

1. A. I. Vogel, 1989, **Textbook of practical organic chemistry** (5^{th} Ed.).

2. F. G. Mann and B.C. 1990, **Saunders, Textbook of practical organic chemistry** (5^{th} Ed.).

PHYSICAL CHEMISTRY PRACTICAL-II

Credits: 2 **Semester: II**
Course Code: MOC26253 **No. of hours/week: 4**

Objectives

- To apply the knowledge of various electro analytical techniques in studying reactions

Course Outcomes

- The student will be able to perform various experiments involving different analytical techniques

S.No.	Name of the Practical	Hours Allotted	Pedagogy
	Conductometry:		
1	Titration of a mixture of strong and weak acids *vs* strong base	2 hrs	Hands on practice
2	Titration of mixture of strong acid, weak acid, and $CuSO_4$ *vs* strong base	2 hrs	Hands on practice
3	Determination of the hydrolysis constant of aniline hydrochloride	2 hrs	Hands on practice
	Potentiometry:		
4	Titration of Fe^{+2} *vs* $Cr_2O_7^{-2}$ (redox titration)	2 hrs	Hands on practice
5	Titration of Cl^- *vs* Ag^+ (precipitation titration)	2 hrs	Hands on practice
6	Determination of single electrode potential	2 hrs	Hands on practice
7	Determination of solubility product	2 hrs	Hands on practice
	pH metry:		
8	Monobasic acids *vs* strong base.	2 hrs	Hands on practice
9	Mixture of acids *vs* strong base	2 hrs	Hands on practice
	Spectrophotometry:		
10	Estimation of Cu (II) using EDTA	2 hrs	Hands on practice
11	Estimation of Fe (II) using 1,10-phenanthroline	2 hrs	Hands on practice
	Chemical kinetics:		
12	Peroxydisulphate - iodide reaction: order w.r.t [I^-] by isolation method	4 hrs	Hands on practice
13	Peroxydisulphate - iodide reaction: order w.r.t [$S_2O_8^{2-}$] by initial rate method	4 hrs	Hands on practice
14	Stoichiometry of peroxydisulphate–iodide reaction	4 hrs	Hands on practice
	Adsorption:	4 hrs	
15	Adsorption of acetic acid on animal charcoal or silica gel	4 hrs	Hands on practice
	Critical Solution Temperature:		
16	Determination of critical solution temperature of the phenol-water system	2 hrs	Hands on practice
17	Effect of added electrolyte on the CST of phenol-water system	2 hrs	Hands on practice

Learning Resources:

1. B. D. Khosla, **Textbook of senior practical physical chemistry** R. Chand & Co. New Delhi
2. Mounir A. Malati, 1999, **Experimental Inorganic/Physical Chemistry–An Investigative integrated approach to Practical Project work**.
3. J.B. Jadav **Advance Physical Practical Chemistry,** Krishna Publisher, A.K. Nad, B. Mahapatra and A. Ghoshal **Advance Course in Practical Chemistry**

ANALYTICAL TECHNIQUES & SPECTROSCOPY PRACTICAL-II

Credits: 2 **Semester: II**

Course Code: MOC26254 **No. of hours/week: 4**

Objectives

- To estimate and analyze various commercial samples and drugs
- To apply knowledge of Column and ion exchange Chromatography
- To interpret the structure of molecules using NMR spectroscopy and Mass spectrometry.

Outcome

- The student will be able to analyze, develop and interpret the various qualitative and quantitative structural techniques.

S.No.	Name of the Practical	Hours Allotted	Pedagogy
	Applied Analysis:		
1	Estimation of alkali content in antacid by Acid Base titration method	4 hrs	Hands on practice
2	Estimation of available oxygen in Hydrogen peroxide by Permanganometry	4 hrs	Hands on practice
3	Estimation of Calcium in milk by Complexometry	4 hrs	Hands on practice
	Ion Exchange Chromatography:	4 hrs	
4	Determination of capacity of an ion exchange resin	4 hrs	Hands on practice
5	Separation of Zinc and Magnesium on an anion exchange resin and estimation of Mg^{2+} and Zn^{2+}	4 hrs	Hands on practice
	Column Chromatography:		
6	Purification of Benzanilide	4 hrs	Hands on practice
7	Purification of Methyl-4- Benzoate	4 hrs	Hands on practice
	Spectral Analysis: Interpretation of spectra from Mass, NMR & IR data of the following representative compounds (minimum two examples each) with help of Molecular formula:		
8	Saturated Hydrocarbons	2 hrs	Analysis of Data
9	Unsaturated Hydrocarbons	2 hrs	Analysis of Data
10	Aromatic Hydrocarbons	2 hrs	Analysis of Data
11	Alcohol	2 hrs	Analysis of Data
12	Aldehydes	2 hrs	Analysis of Data
13	Ketones	2 hrs	Analysis of Data
14	Carboxylic acids	2 hrs	Analysis of Data
15	Amines	2 hrs	Analysis of Data
16	Nitriles	2 hrs	Analysis of Data
17	Esters	2 hrs	Analysis of Data

Learning Resources:

1. R. Mukhopadhyay & P. Chatterjee, 2016, **Advanced practical chemistry,** NCBA books.
2. Gurdeep Raj, 2015, **Advanced Practical Inorganic Chemistry**, GOEL publishing house.
3. Ayodhya Singh,2006, **Advanced experimental Inorganic Chemistry,** Campus books Int.
4. A. I. Vogel, 1989, **Textbook of practical organic chemistry** (5^{th} Ed.).
5. F. G. Mann and B.C. 1990, **Saunders, Textbook of practical organic chemistry** (5^{th} Ed.).
6. Silverstein, Bassler and Morrerl, 1998. **Spectrometric Identification of Organic Compounds.** 5th Edition. John Wiley & Sons.
7. Field, L.D., Sternhell, S. and Kalman J. R. **Organic Structures from Spectra,** 5th Edition, John Wiley & sons.