Syllabus for
M.Sc. Chemistry
(2 Year / 4 Semester)
Programme based on NEP – 2020

(2025 onwards)

Ewing Christian College, Prayagraj
(An Autonomous Constituent PG College of University of Allahabad)

EWING CHRISTIAN COLLEGE, PRAYAGRAJ
DEPARTMENT OF CHEMISTRY

<table>
<tr><th colspan="4">M.Sc. Semester - I</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td>COURSE CODE:
CHE1TH01</td><td>INORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="2">1. Introduce students to advanced theories of coordination chemistry, including bonding models (VBT, CFT, LFT, MOT) and their applications.
2. Develop a strong understanding of electronic structure, crystal field splitting, and related properties of transition metal complexes.
3. Study the stability of complexes in solution, their thermodynamic and kinetic aspects, and experimental methods of determining stability constants.
4. Provide a comparative analysis of lanthanides and actinides, focusing on their coordination chemistry, oxidation states, spectra, and magnetism.
5. Familiarize students with the hard and soft acid-base (HSAB) principle and its role in predicting stability and reactivity of metal complexes.
6. Introduce the principles of molecular luminescence (fluorescence, phosphorescence, photoluminescence) in transition metal and lanthanide complexes.
7. Equip students with the theoretical foundation required for research in inorganic, bioinorganic, and organometallic chemistry.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">1. Explain the bonding models (Valence Bond, Crystal Field, Ligand Field, MO theory) and predict structures, geometrical arrangements, and properties of coordination complexes.
2. Interpret crystal field splitting diagrams in different geometries (octahedral, tetrahedral, square planar, trigonal bipyramidal, etc.) and calculate CFSE for complexes.
3. Analyze M.O. diagrams for transition metal complexes and interpret the spectrochemical series and Jahn-Teller distortions.
4. Evaluate stability constants of metal complexes using Job’s method and mole ratio method and understand thermodynamic correlations and factors influencing stability.</td></tr>
</table>

	5. Compare the chemistry of f-block elements (lanthanides and actinides), including their electronic configurations, coordination chemistry, oxidation states, magnetic and spectral properties. 6. Apply HSAB principle to explain the stability, selectivity, and reactivity of metal-ligand interactions in various systems. 7. Describe the principles of fluorescence, phosphorescence, and photoluminescence of transition metal and lanthanide complexes and relate these properties to energy-level diagrams. 8. Apply theoretical concepts of coordination chemistry to solve advanced problems relevant to material science, catalysis, bioinorganic chemistry, and spectroscopy.
Syllabus	**UNIT-1** **COORDINATION CHEMISTRY:** Theories of Coordinate Linkages: Valence Bond, Crystal Field, Ligand Field and M.0. Theory. Crystal Field splitting of d - orbitals in octahedral, trigonal bipyramidal, square pyramidal, tetragonal and square fields. Crystal field stabilization energy (CFSE). M.0. Energy level diagram for octahedral and tetrahedral complexes (with s bonding only). Spectrochemical series. Jahn Teller effect. **UNIT-2** **STABILITY OF METAL COMPLEXES IN SOLUTION:** Step wise and overall stability constants. Thermodynamic correlations. Determination of stability constants, Job's method of continuous variation and mole ratio method. Factors affecting the stability constants, chelation and its importance. **UNIT-3** **CHEMISTRY OF f- BLOCK ELEMENTS:** Comparative study of Lanthanides and Actinides with special reference to electronic structure, oxidation state, coordination number, structure, stereochemistry and magnetic and spectral properties. General chemistry of Actinides including EFM diagrams. **UNIT-4** **SOFT AND HARD ACIDS AND BASES:** Pearson's concepts, SHAB Principle and its applications. **UNIT-5** **MOLECULAR LUMINESCENCE:** Basic principles of fluorescence emission: characteristics of fluorescence emission (Jablonski diagram: fluorescence and phosphorescence, delayed fluorescence); General properties of fluorescence emission; Parameters of

	fluorescence: fluorescence intensity, fluorescence average lifetime, fluorescence quantum yield and emission maxima; Solvatochromism: effect of solvent polarity on emission spectra, steady state and time resolved fluorescence; Fluorescence quenching: basic idea of fluorescence resonance energy transfer (FRET); Photoluminescence in transition metal complexes (3d series) and zinc (II); Molecular fluorescence as an analytical tool (applications).
Recommended Books	1. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity, (Fourth edition), Published by Pearson Education, Inc. 2. Malik, Tuli, and Madan, Selected Topics in Inorganic Chemistry, S. Chand Publishing Co. 3. F. A. Cotton, Chemical Applications of Group Theory, Wiley Publication. 4. David M. Bishop, Group Theory and Chemistry, Dover Publications, New York. 5. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, (Third Edition), Springer Science. 6. Molecular Fluorescence: Principle and Applications by B. Valeur, 2001. 7. Fundamental of Photochemistry by K. K. Rohatgi − Mukhrejee. 8. Modern Molecular Photochemistry by N. J. Turro.

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<table>
<tr><th colspan="4">M.Sc. Semester - I</th></tr>
<tr><th colspan="4">CHEMISTRY</th></tr>
<tr><th colspan="4">PAPER – II</th></tr>
<tr><td>COURSE CODE:
CHE1TH02</td><td>ORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td colspan="2"></td><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">Provide a theoretical foundation of π-molecular orbital concepts, aromaticity, and reaction mechanisms. Develop advanced knowledge of stereochemistry, chirality, and conformational analysis. Explain mechanistic pathways of aliphatic and aromatic nucleophilic substitutions. Introduce the generation, structure, stability, and reactivity of organic reactive intermediates.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Explain and apply π-molecular orbital theories and aromaticity concepts to conjugated and cyclic systems.
2. Analyse stereochemical features such as chirality, topicity, stereoelectronics, and stereoisomerism in complex molecules.
3. Evaluate conformational stability of alicyclic compounds and heterocycles using stereoelectronic models.
4. Differentiate and predict mechanisms of aliphatic and aromatic nucleophilic substitutions with respect to structural and medium effects.
5. Assess the generation, stability, and reactivity of reactive intermediates and their role in rearrangements and organic transformations.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT – I
π-Molecular Orbitals of Conjugated Systems and Aromaticity:
Qualitative description of molecular orbitals of simple acyclic and monocyclic systems: Huckel and Perturbation molecular orbital theory. Aromaticity in benzenoid, non-benzenoid compounds and metallocenes, Huckels rule, energy of pi-molecular orbitals, annulenes, anti-aromaticity, homo-aromaticity.
Reaction Mechanism: Structure and Reactivity</td></tr>
</table>

A review of reaction mechanisms including methods of determination. Linear free energy relationships and their applications (Hammett equation and modifications). Hard and soft Nucleophiles.

UNIT – II

Stereochemistry

Elements of symmetry, chirality, molecules with more than one chiral centre, threo and erythron isomers, optical purity, Topicity and Prostereoisomerism: Topicity of ligands and faces- homotopic, enantiotropic and Cram's rule/diastereotopic ligands and faces. Optical activity in the absence of chiral carbon: Stereochemistry and configuration of allenes, spiranes, and biphenyls (atropisomerism).

UNIT – III

Conformational Analysis

Factors responsible for the stability of conformation: Torsional strain, steric strain, Dipole dipole interaction, Hydrogen bonding, angle strain, hyperconjugation, and anomeric effect. Cyclostereoisomerism: Configurations, conformations and stability of cyclohexanes (mono-, di-, and trisubstituted), cyclohexenes, cyclohexanones, halo cyclohexanones, decalins, decalols and decalones and conformational effect on reactivity including-Cieplak's Model.

UNIT – IV

Aliphatic Nucleophilic Substitution

The SN2, SN1, mixed SN2, SN1 and SNi mechanisms, The neighbouring group mechanism, neighbouring group participation by σ and Π bonds, anchimeric assistance. Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis, ambident nucleophile and regioselectivity. competition between SN1 and SN2 mechanism

UNIT – V

Reaction intermediate:

Generation, structure, stability, and reactivity of carbene (electrophilic and nucleophilic), nitrene, carbanion (enolate ion), non-classical carbocations-phenonium ions, norbornyl system, common carbocation rearrangement. Aromatic Nucleophilic Substitution: The Ar SN1, ArSN2, and benzyne mechanisms, Reactivity- effect of substrate structure, leaving group and

	attacking nucleophile. The von Richter, Sommelet-Hauser, Smiles rearrangements and Bucherer Reaction.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002. 2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 3. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Prentice Hall, 2011. 4. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 5. Ernest L Eliel, Samuel H. Wilen, Stereochemistry of organic compounds, Wiley India Edition, 2008. 6. March, J. Advanced Organic Chemistry John Wiley & Sons (1992). 7. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 8. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2004). 9. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi. 10. Advanced Organic Chemistry by Prof. J. Singh & Prof. L.D.S. Yadav.

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<tr><th colspan="4">M.Sc. Semester - I</th></tr>
<tr><td colspan="4">CHEMISTRY</td></tr>
<tr><td colspan="4">PAPER – III</td></tr>
<tr><td>COURSE CODE:
CHE1TH03</td><td>PHYSICAL CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Develop a deep understanding of advanced thermodynamic principles, including the Third Law and its implications.
2. Introduce the foundational concepts and mathematical formulation of quantum mechanics, with application to chemical systems.
3. Familiarize students with molecular spectroscopy techniques and the interpretation of spectral data for molecular structure analysis.
4. Provide detailed insight into rotational and vibrational spectroscopy, including instrumentation and selection rules.
5. Introduce the principles and kinetics of polymer chemistry, and methods for determining polymer molecular weights.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Explain the Third Law of Thermodynamics and apply Nernst Heat Theorem to calculate entropy changes, especially in non-condensed systems.
2. Analyze partial molar properties and chemical potential to understand the thermodynamic behavior of mixtures and solutions.
3. Apply classical and quantum models (like Planck’s law and Schrödinger equation) to explain atomic and molecular systems.
4. Solve quantum mechanical problems involving particle in a box, harmonic oscillator, and hydrogen-like atoms using appropriate boundary conditions.
5. Use approximate quantum methods such as the variation principle to estimate ground state energies of atoms.
6. Interpret rotational spectra of diatomic and polyatomic molecules, and determine molecular parameters like bond lengths and moments of inertia.
7. Analyze vibrational spectra using harmonic and anharmonic oscillator models, including P, Q, R branches of vibration-rotation transitions.
8. Identify and explain the normal modes of molecular vibrations in polyatomic molecules and their activity in IR spectroscopy.
9. Understand the types and kinetics of polymerization reactions, especially step-growth polymerization and molecular weight distribution.
10. Determine the molecular weights of the polymers using experimental techniques like osmotic pressure, light scattering, and viscosity methods.</td></tr>
</table>

Syllabus

UNIT – I

Advanced Thermodynamics

Nernst Heat Theorem and its application to non-condensed systems, Statements of the Third Law of Thermodynamics, Derivation of unattainability of absolute zero, Partial molar properties and chemical potential, Determination of entropy from the Third Law using the correction due to gas imperfections. Raoult's law, Henry's law, solubility behaviour of ideal solutions.

UNIT – II

Quantum Chemistry

Black body radiation, Wien and Rayleigh-Jeans laws, Planck's law and energy of harmonic oscillator according to classical mechanics, Origin of quantum theory, Postulates of quantum mechanics, Three dimensional time independent Schrodinger wave equation, Eigen functions and eigen values, Normalization and Orthogonality conditions, Particle in 1-D & 3-D box, One dimensional harmonic oscillator, Tunnel effect, Eigen function and eigen value of H-atom (Solutions not required), shapes of s, p, d and f- orbitals.

Approximate Methods- Variation principle and its application to ground state H-atom, Radial and Angular distribution curves for H-atom.

UNIT – III

Spectroscopy-I

Molecular Spectra: Basic concepts of molecular spectroscopy, Classification of spectra, Characterization of electromagnetic radiations, Regions of the spectrum,

Rotational (Microwave) Spectroscopy: Principal moment of inertia, classification of rotors: rigid and non-rigid rotor, selection rule (rigid rotor), Centrifugal distortion, Isotopic shift, Spectra of polyatomic molecules, Rotational constant, effect of isotopic substitution frequencies, linear polyatomic molecules, non-linear polyatomic molecules, symmetric and asymmetric Top molecules, relative intensities of spectral lines, stark effect, instrumentation and application.

UNIT – IV

Spectroscopy-II

Vibrational Spectroscopy: Energy levels of simple harmonic oscillator, vibrational motion of a diatomic molecule, zero-point energy Force constant and bond strengths, Anharmonic oscillator, Morse potential energy diagram, Hot bands, selection rules, Vibration-rotation spectroscopy, vibrational – rotational spectra of a diatomic molecule and poly atomic molecule PQR Branches, Normal Modes of molecular vibrations.

UNIT – V

Polymer Chemistry

Introduction of type of polymers, Step polymerization, Kinetics of step polymerization, Molecular weight distribution in linear polycondensation

	(Derivation of size distribution), Molecular weight averages, Method of determining the molecular weight by osmotic pressure, Light scattering, Sedimentation and Viscosity methods.
Recommended Books	1. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press. 2. Levine, I. N., Quantum Chemistry 7th Ed., USA, Pearson Education. 3. McQuarrie, D. A. & Simon, J. D. Physical Chemistry: A Molecular Approach 3rd Ed., Univ. Science. 4. Castellan, G.W., Physical Chemistry 3rd Ed., USA, Addison-Wesley Publishing Company. 5. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry 1 (Ionics), Springer. 6. Banwell, C.N., & Mc Cash, Elaine M., Fundamental of molecular spectroscopy 3rd Ed., UK. Mc Graw-Hill Companies. 7. Barrow, G.M., Introduction to molecular spectroscopy. USA, Mc Graw-Hill Companies. 8. Hollas, J.M., Modern spectroscopy 4th Ed., USA, John Wiley & Sons Ltd. 9. Brown, J. M., Rotational spectroscopy of diatomic molecules, UK, Cambridge University Press. 10. Donald A Mc Quarrie and John D Simon, Physical Chemistry: A molecular approach, University Science Books Sausalito, California.

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<table>
<tr><th colspan="4">M.Sc. Semester - I</th></tr>
<tr><th colspan="4">PAPER – IV</th></tr>
<tr><td>COURSE CODE:
CHE1TH04</td><td>ANALYTICAL CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 Hours = 45)</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 75</td><td>THEORY: 50
C.I.A.: 25</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:

1. Provide fundamental understanding of analytical chemistry, its principles, and role in chemical analysis.
2. Develop knowledge of data handling techniques, accuracy, precision, and error analysis in analytical work.
3. Introduce volumetric methods of analysis with emphasis on theory of titrations, indicators, and modern extensions.
4. Familiarize students with gravimetric methods, principles of precipitation, and role of organic precipitants.
5. Impart understanding of spectrochemical methods including UV-Vis, FT-IR, and Raman spectroscopy, with emphasis on their applications in qualitative and quantitative analysis.
6. Build skills to apply chemical equilibrium concepts, buffer systems, and instrument-based methods in problem solving.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">On successful completion of the course, the learner will be able to:

1. Explain the fundamentals of analytical chemistry, types of analytical methods, sampling procedures, and parameters such as sensitivity and selectivity.
2. Evaluate accuracy, precision, errors, and statistical data treatment methods including regression analysis and detection limits.
3. Perform and interpret volumetric titrations (acid-base, redox, precipitation, and complexometric) with appropriate choice of indicators and techniques such as conductometric titration.
4. Apply the principles of gravimetric analysis to carry out quantitative estimations, understanding coprecipitation, post-precipitation, and the role of organic precipitants.</td></tr>
</table>

	5. Analyze the theoretical basis and applications of UV-Vis, IR, and Raman spectroscopy in structural elucidation of molecules. *6.* Integrate different analytical techniques (classical and instrumental) to solve chemical analysis problems in research and industrial contexts.
Syllabus	**UNIT – I (Fundamentals of Chemical Analysis)** Analytical chemistry and chemical analysis, Classification of analytical methods, Method selection, Sampling, Qualitative and Quantitative Analysis, Sensitivity and Selectivity of Analytical Methods, Sampling; Buffer solutions, Equilibrium constants in analysis. **UNIT – II (Data Handling in Analytical Chemistry)** Accuracy and Precision; Determinate and Indeterminate errors; Significant figures, Rounding off figures; Standard deviation; Propagation of errors, Regression analysis; Detection limit evaluation. **UNIT-III (Volumetric methods of analysis)** Standard solutions; Acid-base, redox, precipitation, complexometric and chelatometric titrations; conductometric titration, Theory of Indicators – Mixed Indicators and Fluorescent Indicators. **UNIT-IV (Gravimetric Methods of Analysis)** Weight relationships; Principles and scope of gravimetric methods; Conditions of Impurities in precipitates – Coprecipitation and post precipitation; Washing, filtering and drying of precipitates; Role of organic precipitants in gravimetric analysis, important organic precipitants: Dimethylglyoxime, cupferron, 8-Hydroxyquinoline, salicylaldoxime, 1-nitroso 2-naphthol, Anthranic acid, α-benzoinoxime (Cupron), Sodium tetraphenylboron. **UNIT-V (Spectrochemical Methods)** Atomic and Molecular Spectroscopy, Instrumentation and working of UV-Vis spectroscopy, Absorption by Isolated chromophores and conjugated chromophores, Spectral shifts, Absorption due to metal complex formation (d-d transition, charge transfer processes). Job's method of continuous variation, mole ratio and slope ratio analysis, Beer-Lambert law, Its limitations and applications, Infrared spectroscopy, Structural analysis using UV-Vis and FT-IR spectroscopy.Raman Spectroscopy: Basic theory and applications. Complementarity of IR and Raman spectra (Mutual exclusion principle).
Reference Books	1. . D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.

	2. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York. 3. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition (2000), Wiley, New York. 4. Spectroscopy of Organic Compounds by P. S. Kalsi.

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<table>
<tr><th colspan="4">M.Sc. Semester - II</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td>COURSE CODE:
CHE2TH01</td><td>INORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 4
HOURS: 4 x 15 Hours = 60 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. Provide a strong foundation in molecular symmetry and group theory to analyze chemical structures and bonding.
2. Develop understanding of electronic spectroscopy, term symbols, and selection rules to interpret atomic and molecular spectra.
3. Introduce the theory and application of electronic spectra of transition metal complexes using Orgel and Tanabe-Sugano diagrams.
4. Familiarize students with the mechanisms of substitution and redox reactions in transition metal complexes.
5. Correlate theoretical principles with practical aspects of coordination chemistry, enabling students to predict reactivity, stability, and spectroscopic properties of complexes.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">1. Identify and apply symmetry elements, operations, and character tables to simple inorganic and coordination compounds.
2. Explain the Frank-Condon principle, spin and Laporte selection rules, and predict band intensities and widths in electronic spectra.
3. Derive and assign term symbols for atoms/ions, and analyze the effect of spin-orbit coupling in different electronic configurations.
4. Interpret the electronic spectra of transition metal complexes using Orgel and Tanabe-Sugano diagrams, and calculate crystal field and ligand field parameters (Dq, B, β).
5. Differentiate between inert and labile complexes, and explain the mechanisms of acid/base hydrolysis and substitution in octahedral complexes.
6. Evaluate substitution reactions in square planar complexes and apply the trans effect to predict reaction pathways.
7. Analyze the mechanism of redox reactions, including one-electron transfer processes, outer-sphere and inner-sphere mechanisms, and apply Marcus-Hush theory to electron transfer.</td></tr>
</table>

	8. Integrate knowledge of **symmetry, spectroscopy, and reaction mechanisms** to predict and rationalize the properties and reactivities of transition metal complexes.
Syllabus	**UNIT-1** **Molecular Symmetry:** Symmetry elements and operations, symmetry groups, defining properties of a group, character tables and its applications. The great orthogonality theorem and its importance. Symmetry considerations in simple inorganic and coordination compounds. **UNIT-2** **Term Symbols and Basic Principles of Electronic Spectroscopy:** Frank - Condon principle, spin and Laporte selection rules, band intensities, band width. Number of microstates and term symbols for gaseous atoms/ions. Spin-orbit coupling in spectroscopic ground state of p^2 and d^2 configurations and energies of J levels. **UNIT-3** **Electronic Spectra of Transition Metal complexes:** Interpretation of electronic spectra, using Orgel and Tanabe-Sugano diagram for 3d Transition Metal complexes. Calculation of crystal field and ligand field parameters (Dq, B and ß parameters), nephelauxetic series and charge transfer spectra. **UNIT-4** **Reaction Mechanism of Transition Metal Complexes:** Inert and Labile complexes, mechanism of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct indirect evidence in favor of conjugate mechanism. **UNIT-5** **Reaction Mechanism**: Anation reactions, reactions without metal-ligand bond cleavage, substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reactions: redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.
Recommended Books	1. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity. 2. Keith F. Purcell and John C. Kotz, Inorganic Chemistry. 3. Gary Wulfsberg, Inorganic Chemistry, Viva Student Edition.

	4. W. H. Malik, G. D. Tuli, and R. D. Madan, Selected Topics in Inorganic Chemistry, S. Chand and Company Limited. 5. J. D. Lee, Inorganic Chemistry. 6. S. K. Aggarwal and Keemti Lal, UGC Advanced Inorganic Chemistry, Pragati Prakashan.

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<table>
<tr><th colspan="4">M.Sc. Semester - II</th></tr>
<tr><td colspan="4">CHEMISTRY</td></tr>
<tr><td colspan="4">PAPER – II</td></tr>
<tr><td>COURSE CODE:
CHE2TH02</td><td>ORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="3">Introduce the generation, stability, and reactivity of free radicals and their applications in organic synthesis. Provide mechanistic and stereochemical insights into addition and elimination reactions. Develop an understanding of enolate chemistry and its stereoselective synthetic applications. Explain the principles, classification, and stereo electronic basis of pericyclic reactions. Apply frontier molecular orbital (FMO) theory and Woodward–Hoffmann rules to analyse organic transformations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After completing this course, students will be able to:
1. Explain and analyse the structure, stability, and mechanistic pathways of free radical reactions and their synthetic significance.
2. Apply stereoelectronic principles to predict the outcome of addition and elimination reactions, including regio- and stereoselectivity.
3. Evaluate enolate ion chemistry and stereoselective carbon–carbon bond-forming reactions (Aldol, Wittig, Stobbe, etc.).
4. Classify and interpret pericyclic reactions using FMO and Woodward–Hoffmann rules (electrocyclic, cycloaddition, sigmatropic).
5. Solve mechanism-based problems involving radical, elimination, and pericyclic reactions, integrating theory with synthetic applications.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT-I

Free Radical Reactions

Generation, structure, stability and reactions of free radicals- Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes, Free radical rearrangement, Hunsdiecker reaction. Cage effects; radical-cations & radical-anions, SRN1substitution processes.</td></tr>
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Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspect of addition reaction involving electrophiles, nucleophiles and free radicals. Regio and chemo selectivity reactivity and stereochemical orientation with following reactions: Addition to cyclopropane ring. addition relations on alkenes including cyclohexene such as-Hydroboration, epoxidation, hydroxylation, Michael reaction, hydrogenation.

UNIT-II

Addition to Carbon-Hetero Atom Multiple Bonds

Generation of enolate ions and their synthetic applications including stereochemical aspect. Stereochemistry of Wittig, Aldol condensation reactions (Zimmerman-Traxler model). Stobbe Condensation reaction, reaction mechanism of hydrolysis of esters.

Elimination Reactions

The E2, E1 and E1cB mechanisms and their stereochemistry and orientation. Reactivity- effects of substrates, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination and Peterson elimination. Substitution vs elimination reactions.

UNIT-III

Pericyclic Reactions I:

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1,3,5- hexatriene and allyl system, Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO and PMO approach of pericyclic reactions under thermal and photochemical conditions, Electrocyclic reactions-conrotatory and disrotatory motions of 4n, 4n+2 and allyl systems.

UNIT-IV

Pericyclic Reactions II:

Cycloadditions- suprafacial and antrafacial additions, [2+2] and [4+2] reactions (*hv* and Δ), stereochemistry and orientation effects in Diels Alder reaction. [2+2] addition of ketenes, 1,3-dipolor cycloadditions and cheleotropic reactions.

UNIT-V

	Pericyclic Reactions III: Sigmatropic rearrangement-Suprafacial and antarafacial shift of Hydrogen, sigmatropic shifts involving carbon moieties, retention and inversion of configuration, [3,3] and [5,5] sigmatropic rearrangements, Claisen, Cope and Aza-Cope-rearrangements. Problems on pericyclic reactions.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002 2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 3. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Prentice Hall, 2011. 4. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 5. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 6. F.A. Carey, & R. J. Sundberg, Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2004). 7. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi. 8. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999). 9. Carruthers, W. Modern Methods of Organic Synthesis Cambridge University Press (1996). 10. Advanced Organic Chemistry by Prof. J. Singh & Prof. L.D.S. Yadav. 11. Photochemistry and Pericyclic Reactions, Prof. Jagdamba Singh and Dr. J. Singh.

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<tr><td>COURSE CODE:
CHE2TH03</td><td>PHYSICAL CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td colspan="2"></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Introduce the foundational principles of statistical mechanics and demonstrate how quantum states influence thermodynamic properties.
2. Explain and compare various chemical kinetics theories, and analyze the factors affecting reaction rates in ionic systems.
3. Examine photochemical processes, including excited states and chain reactions, with real-life applications in chemical systems.
4. Illustrate electrochemical concepts such as ionic activities, Debye-Hückel theory, and their implications for solution chemistry.
5. Describe and analyze the solid-state structure of materials, including crystal symmetry, defects, and X-ray diffraction principles.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">Upon successful completion of this course, the student will be able to:
1. Understand the concepts of quantum states, complexions, and the role of indistinguishability in statistical mechanics.
2. Apply Maxwell-Boltzmann statistics and calculate thermodynamic properties using partition functions (translational, rotational, vibrational, nuclear, and electronic).
3. Analyze chemical reaction rates using collision theory and transition state theory, including salt effects and dielectric influence.
4. Compare and evaluate the theoretical frameworks of absolute reaction rate theory for atomic and molecular reactions.
5. Explain the behavior of excited states and photophysical processes such as photoluminescence and photosensitization in photochemistry.
6. Distinguish between chain and non-chain photochemical reactions and interpret their mechanisms (e.g., H_2–Cl_2, H_2–Br_2 systems).
7. Apply Debye-Hückel theory to determine activity coefficients and assess ionic interactions in dilute and concentrated electrolyte solutions.
8. Interpret the structure of solids based on symmetry, bonding, Miller indices, and cohesive energy concepts.
9. Utilize Bragg’s Law and X-ray diffraction techniques for structural analysis of crystalline materials such as NaCl.
10. Identify and classify different types of crystal defects (Schottky, Frenkel, metal excess/deficiency) and their effects on material properties.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT-I
Statistical Mechanics: Quantum states and complexions, The combinatory rule, System with definite total energy, Degeneracy of energy levels,</td></tr>
</table>

	Probability and most probable distribution, Indistinguishability, Maxwell-Boltzmann statistics, partition function, Translational, rotational, vibrational, nuclear and electronic partition functions, Internal energy and heat capacity in terms of partition function. **UNIT-II** **Chemical Kinetics:** Collision theory, Comparison of collision and absolute reaction rate theories, Primary and Secondary salt effects in the light of mechanistic tests, The theory of Absolute reaction rates - for reactions between atoms and reactions between molecules in terms of partition function, Influence of ionic strength and dielectric constant, Explosive reactions. **UNIT-III** **Photochemistry:** Primary and secondary processes in photochemistry, Fate and properties of excited states, Photolumineseence and Photostationary state, Photosensitization, Rice – Herzfeld mechanisms. Photochemical chain reactions (hydrogen and chlorine, hydrogen and bromine) Non-chain photochemical reactions (formation of phosgene, decomposition of H_2O_2 in presence of CO). **UNIT-IV** **Electrochemistry:** Limitation of Arrhenius theory of electrolytic dissociation, Role of solvent and inter-ionic forces, activities and activity coefficients, determination of activity coefficients, DebyeHuckel Theory of the structure of dilute ionic solution, charge density and electrical potential, Properties of ionic cloud, activity coefficients from Debye-Huckel theory, Limiting law and its verification, Debye-Huckel Theory to more concentrated solutions. **UNIT-V** **Solid State:** Classification, Crystal structures, Symmetry, Bonding in solids, Miller indices, Cohesive energy of ionic crystal, Lattice energy of crystals, Bragg's equation, X-ray analysis of NaCl crystal, Defects in crystal (Schottky, Frenkel, Metal Excess, and Metal Deficiency defects).
Recommended Books	1. McQuarrie, D. A. Statistical Mechanics, Viva Books Pvt. Ltd.: New Delhi. 2. Bagchi B. Statistical Mechanics for Chemistry and Material Science, CRC Press. 3. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd Ed. 4. Laidler, K. J. Chemical Kinetics 3rd Ed., Benjamin Cummings. 5. Billmeyer, F. W. Textbook of Polymer Science 3rd Ed. Wiley-Interscience: New York. 6. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press. 7. Fundamentals of photo chemistry, K.K. Rothagi-Mukheriji, 3rd Ed., New Age Publishers. 8. Essentials of Molecular Photochemistry, A Gilbert and J. Baggott, Blackwell Scientific. 9. Molecular Photochemistry, N. J. Turro, University Science Books.

	10. Introductory Photochemistry, A. Cox and t. Camp, McGraw Hill. 11. West, A. R. Solid State Chemistry and its Applications 2nd Ed., John Wiley & Sons Ltd. 12. Gowarikar, V.R., Vishwanathan, N.V., & Sridhar, J. Introduction to polymer science, New York, John Wiley & Sons. 13. C.W. Bunn. Chemical Crystallography. Oxford at the Clarendon Press.

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<table>
<tr><th colspan="4">M.Sc. Semester – II</th></tr>
<tr><th colspan="4">PAPER – IV</th></tr>
<tr><td rowspan="2">COURSE CODE:
CHE2TH04</td><td rowspan="2">ANALYTICAL CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 Hours = 45)</td></tr>
<tr><td>TOTAL MARKS: 75</td><td>THEORY: 50
C.I.A.: 25</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:

1. Provide fundamental understanding of separation techniques such as solvent extraction and chromatography.
2. Train students in chromatographic methods including paper, TLC, column, ion-exchange, GC, and HPLC.
3. Familiarize students with principles and applications of potentiometry, pH measurements, and electrodes.
4. Introduce concepts of electroanalytical methods, galvanic cells, electrode processes, electrogravimetry, and electrocatalysis.
5. Develop knowledge of spectroscopic techniques (NMR, mass spectrometry) for structural elucidation of compounds.
6. Provide hands-on experience in spot test analysis for detection of elements, metal ions, and functional groups in organic compounds.
7. Build analytical skills to integrate different instrumental and classical methods for qualitative and quantitative analysis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">On successful completion of the course, the learner will be able to:

1. Explain the principles of solvent extraction and various chromatographic techniques (paper, TLC, column, ion-exchange, GC, HPLC).
2. Apply chromatographic methods to separate and identify components of chemical mixtures.
3. Demonstrate the use of potentiometric electrodes and potentiometric titrations in chemical analysis.
4. Evaluate electrode behavior, Nernst equation, overpotential, and electrocatalytic processes (O_2 reduction, O_2 evolution, H_2 evolution, CO_2 reduction).</td></tr>
</table>

	5. Perform electroanalytical techniques like electrogravimetry and electrodeposition for quantitative estimation. 6. Interpret spectroscopic data (^{1}H NMR, ^{13}C NMR, mass spectra) for identification of organic compounds. 7. Analyze molecular fragmentation patterns and rearrangements (e.g., McLafferty rearrangement) in mass spectrometry. 8. Employ spot tests for qualitative analysis of elements, functional groups, and organic compounds. 9. Integrate classical and modern instrumental methods for solving complex analytical problems.
Syllabus	**UNIT-I (Fundamentals of separation techniques)** Solvent extraction, Chromatography separation: Principle and classifications of chromatography, Basics about Paper chromatography, Thin layer chromatography (TLC), Column chromatography, Ion exchange chromatography, GC, HPLC. **UNIT-II (Potentiometry)** Potentiometric Electrodes: Metal Electrodes, Metal – Metal Electrodes, Metal-Metal Salt Electrodes for measuring the Salt's Anion, Redox Electrodes, Reference Electrodes, Potentiometric titrations, Potentiometers and pH meter, Glass pH Electrode and its applications; Alkaline Error and Acid Error. **UNIT-III (Fundamentals of electroanalytical and electrocatalytic processes)** Introduction to Electroanalytical methods: Nernst Equation, Origin of EMF of a galvanic cell, Polarizable and non-polarizable electrodes, The concept of overpotential, Electrochemical reactions under mass transfer control, Electrochemical reactions under charge transfer control. Electrogravimetry & electrodeposition. Electrocatalytic processes: oxygen reduction reactions, oxygen evolution reactions, hydrogen evolution reactions, and CO_2 reduction. **UNIT-IV (Spectroscopic analysis of compounds)** Nuclear magnetic resonance (NMR) spectroscopy of compounds (1H and 13C NMR): Chemical shift, Shielding and deshielding effect, Mass spectrometry, Molecular ion peak, base peak and isotopic peaks, Fragmentation modes and rearrangement of ions. McLafferty rearrangement, Mass spectra of certain chemical classes. Identification of organic compounds using a combination

	of spectral data. **UNIT-V (Spot test analysis)** Spot tests for elements present in organic compounds, spot tests for metal ions. Spot tests for identification of functional groups – hydroxy, aldehyde, ketone, carboxylic, nitro and amino. Determination of elements in organic compounds: Semimicro determination of carbon, hydrogen, oxygen, Halogen and nitrogen.
Reference Books	1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London. 2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York. 3. Spectroscopy of Organic Compounds by P. S. Kalsi. 4. J.M. Hollas, Modern Spectroscopy, 3rd Edition (1996), John Wiley, New York.

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<table>
<tr><th colspan="4">M.Sc. Semester – III (INORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td rowspan="2">COURSE CODE:
CHE3TH01</td><td rowspan="2">BIOINORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To understand the fundamental role of metal ions in biological systems and their importance in life processes.
2. To study biologically important metal complexes such as porphyrins, chlorophyll, Vitamin B_{12}, and plastocyanin.
3. To examine the structure and function of oxygen-carrying metalloproteins including haemoglobin, myoglobin, hemerythrin, and hemocyanin.
4. To understand electron transport mechanisms in iron–sulfur proteins and cytochromes.
5. To analyze the structure and catalytic mechanisms of important metalloenzymes containing Mo, Fe, Cu, and Zn.
6. To correlate bioinorganic concepts with synthetic oxygen carriers and biomimetic model complexes.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Explain the biological significance of metal ions including Na^+/K^+ pump, oxygen evolving complex, and nitrogen fixation.
2. Describe the structure and function of biologically important coordination compounds such as porphyrins, chlorophylls, and Vitamin B_{12}.
3. Interpret the mechanism of oxygen binding in haemoglobin including T and R states, cooperativity, Bohr effect, and Hill coefficient.
4. Differentiate between various oxygen-carrying proteins and explain the role of proximal and distal histidine in heme proteins.
5. Explain electron transfer processes in iron–sulfur proteins and cytochromes.
6. Describe the catalytic mechanisms of Mo-, Fe-, Cu-, and Zn-containing metalloenzymes.
7. Compare natural oxygen carriers with synthetic model complexes such as Vaska’s complex and Cobalt (II) Schiff base complexes.</td></tr>
</table>

	8. Apply bioinorganic principles to understand biological redox processes and enzymatic catalysis.
Syllabus	**UNIT-I (Role of Metal Ions in Biological Systems)** Role of metal ions in biological systems; Na^+/K^+ pump; Photosystems: Oxygen Evolving Complex; Nitrogen fixation. **UNIT-II (Complexes of Biological Importance)** Complexes of biological significance: Metal complexes of porphyrins and phthalocyanin; Vitamin B_{12} and B_6; Chlorophylls; Plastocyanin and related pigments. **UNIT-III (Metalloproteins)** Oxygen carrying metalloproteins: haemoglobin (features of heme and apoprotein, oxygenated and deoxygenated form, T and R State, mechanism of heme oxidation, role of proximal and distal histidine, nature of heme-oxygen binding, cooperativity effect, Bohr's effect, Hill coefficient), myoglobin, hemerythrins and hemocyanin; Electron transport protein (Iron–Sulfur Proteins): rubredoxin, ferrodoxins, cytochromes (types a, b and c); Some synthetic oxygen carriers: Vaska's complex, Collman's compound and Cobalt(II)-Schiff base complexes. **UNIT-IV (Metalloenzymes-I)** Molybdenum (Mo) containing metalloenzymes: nitrogenase, xanthine oxidase, sulphite oxidase and nitrate reductase; Iron (Fe) containing metalloenzymes: cytochrome oxidase, catalases, peroxidases, cytochrome P450. **UNIT-V (Metalloenzymes-II)** Copper (Cu) containing enzymes: superoxide dismutase (SOD), ascorbic acid oxidase; Zinc (Zn) containing enzymes: carboxypeptidase A and B, carbonic anhydrase and urease.
Recommended Books	1. Keith F. Purcell and John C. Kotz, Inorganic Chemistry. 2. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity. 3. A. K. Das, Bioinorganic Chemistry, Books and Allied (P) Ltd. 4. K. Hussain Reddy, Bioinorganic Chemistry.

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<table>
<tr><th colspan="4">M.Sc. Semester – III (INORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><td colspan="4">PAPER – II</td></tr>
<tr><td rowspan="2">COURSE CODE:
CHE3TH02</td><td rowspan="2">ORGANOMETALLIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To understand the classification, bonding, and fundamental concepts of organometallic compounds based on hapticity and metal–carbon bond polarity.
2. To apply electron counting methods including EAN and the 18-electron rule and understand their limitations.
3. To study the structure, bonding, and reactivity of σ- and π-bonded organometallic complexes.
4. To understand the mechanisms of important organometallic reactions such as oxidative addition, reductive elimination, olefin insertion, and β-hydride elimination.
5. To analyze homogeneous and heterogeneous catalytic processes and important industrial catalytic cycles.
6. To understand fluxional behavior and applications of organometallic compounds in catalysis and polymerization.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Classify organometallic compounds based on hapticity and nature of the metal–carbon bond and explain their general characteristics.
2. Apply the EAN rule and 18-electron rule to predict stability, oxidation state, coordination number, and geometry of complexes.
3. Describe the bonding and structural features of alkene, alkyne, allyl, dienyl, arene complexes, and metallocenes.
4. Explain key reaction mechanisms including oxidative addition, reductive elimination, olefin insertion, and β-hydride elimination.
5. Interpret catalytic cycles of industrial processes such as Wacker, Monsanto, Cativa, hydroformylation, Fischer–Tropsch, and Ziegler–Natta polymerization.
6. Explain the concept of metal hydrides, dihydrogen complexes, agostic interactions, and C–H bond activation.</td></tr>
</table>

	7. Analyze fluxional behavior and dynamic equilibria in organometallic complexes. 8. Evaluate applications of organometallic chemistry in alkene metathesis, polymerization, CO and CO_2 activation, and industrial catalysis.
Syllabus	**UNIT-I (Organometallics-I)** Classification of organometallic compounds based on hapticity and polarity of M-C bond; EAN and 18 electron rule with limitations; Electron counting in reactions: oxidation state, coordination number and geometry; Effects of complexation; Nomenclature and general characteristics. **UNIT-II (Organometallics-II)** Complexes of σ- and π- donor organic ligands; Transition metal with alkenyls, alkynyls, carbenes, carbynes; Preparation, bonding and structure of alkene, alkyne, allyl, dienyl and arene complexes with metal; Metallocenes; Important reactions: oxidative addition, reductive elimination, olefin insertion and β-hydride elimination. **UNIT-III (Homogeneous and Heterogeneous Catalysis)** Transition metal compounds in homogeneous catalysis and compounds with M-H bond; Catalytic cycle; Hydrogenation; Alkene hydrosilylation and hydroboration; Alkene hydrocyanation; Hydroformylation; Coupling reactions; Heterogeneous catalysis: Fischer-Tropsch reaction and Zeigler-Natta polymerization of olefins. **UNIT-IV (Catalytic Cycle)** Wacker Process; The Monsanto process; Cativa Process; Hydrocarbonylation of olefins; Oxopalladation reactions; Activation of C-H bond; Metal hydrides (classical and non-classical); Dihydrogen complexes; Agostic interaction. **UNIT-V (Fluxionality)** Fluxional organometallic compounds and fluxionality; Dynamic equilibria in compounds such as η^2–olefins and η^3–allyl and dienyl complexes; Applications: alkene metathesis, dimerization, oligomerization and polymerization of alkenes, and activation of CO and CO_2.
Recommended Books	1. Dirk Steinborn, Fundamentals of Organometallic Catalysis, 2012, Wiley-VCH, ISBN: 978-3-527-32717-1. 2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals.

	3. A. Yamamoto, Organotransition Metal Chemistry: Fundamental Concept and Applications, John Wiley, 1986. 4. B. D. Gupta and A. J. Elias, Basic Organometallic Chemistry: Concepts, Synthesis and Application, 2013, ISBN: 978-81-7371-709-3.

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<table>
<tr><th colspan="4">M.Sc. Semester – III (INORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – III</th></tr>
<tr><td>COURSE CODE:
CHE3TH03</td><td>COORDINATION POLYMERS, CAGES, CLUSTERS AND NANOSTRUCTURES</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To understand the principles, classification, synthesis, and applications of metal–organic frameworks (MOFs) and related coordination polymers.
2. To study the structure, bonding, symmetry, and reactivity of metal carbonyls and related compounds.
3. To understand the bonding and structural principles of boranes, carboranes, and metalloboranes using Wade’s and Jemmis’ rules.
4. To learn the classification, preparation methods, and applications of nanoparticles in chemistry and materials science.
5. To study the structural and catalytic properties of metal alkoxides and their industrial importance.
6. To integrate concepts of coordination chemistry, cluster chemistry, and nanoscience for advanced material applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Differentiate between MOFs and COFs and explain their classification, synthesis methods, and post-synthetic modifications.
2. Apply spectroscopic and physical characterization techniques for structural analysis of MOFs and coordination polymers.
3. Explain bonding, symmetry, and vibrational characteristics of metal carbonyls and metal nitrosyl complexes.
4. Predict structures of boranes and related clusters using molecular orbital concepts, Wade’s rules, Jemmis’ rules, and STYX code.
5. Describe various physical and chemical methods for nanoparticle synthesis including sol–gel, wet chemical synthesis, GVD, and CVD.
6. Evaluate applications of nanoparticles in medical, catalytic, and electronic fields.
7. Explain structural features, catalytic behavior, and industrial applications of metal alkoxides.</td></tr>
</table>

	8. Integrate coordination chemistry and nanostructured materials concepts for advanced research and technological applications.
Syllabus	**UNIT-I (Metal-organic Frameworks)** Metal-organic frameworks (MOFs): history, discovery, nomenclature and terminology; Difference between metal-organic frameworks (MOFs) and covalent-organic frameworks (COFs); Classification of MOFs; Synthetic strategies of MOFs: different high temperature and ambient temperature synthetic methods and post synthetic modification of the MOFs; Characterization of MOFs using spectroscopic and physical characterization techniques; Applications of MOFs for gas storage and capturing, separation, heterogeneous catalysis, water purifications and in advanced fields. **UNIT-II (Metal Carbonyls)** Metal carbonyls and related compounds: preparation, structure and properties; Bonding in metal carbonyls; Symmetry of metal carbonyls; Variants of CO bridging vibrational spectra of metal carbonyls; Principle reaction types of metal carbonyls and metal nitrosyl. **UNIT-III (Boron Chemistry)** Molecular orbital diagram of diborane; Polyhedral boranes: structure and bonding in higher boranes, carboranes, metallo-boranes, metallo-carboranes; Wade's and Jemmis' Rules; STYX code. **UNIT-IV (Nanoparticles)** Nanoparticles: introduction, classification, methods of preparation: physical and chemical methods viz. sol-gel; wet chemical synthesis; GVD; CVD and applications (medical and electrical) in chemistry. **UNIT-V (Metal-Alkoxides)** Metal-Alkoxides: properties, structural and catalytic aspects; Industrial applications of various types of metalalkoxides.
Recommended Books	1. Stefan Kaskel, The Chemistry of Metal–Organic Frameworks: Synthesis, Characterization, and Applications (Volume 1), Wiley-VCH Verlag GmbH& Co. KGaA 2. Ali Morsali and Sayed Ali Akbar Razavi, Functional Metal-Organic Frameworks: Structure, Properties and Applications, Scrivener Publishing-Wiley.

	3. Omar M. Yaghi, Markus J. Kalmutzki and Christian S. Diercks, Metal-Organic Frameworks and Covalent Organic Frameworks: Synthesis, Characterization, and Applications, Wiley-VCH Verlag GmbH& Co. KGaA. 4. Stuart R. Batten, Suzanne M. Neville and David R. Turner, Coordination Polymers: Design, Analysis and Application, 2009. 5. Glen E. Rodgers, Inorganic Chemistry. 6. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity, 4th edition, Published by Pearson Education, Inc. 7. J. D. Lee, Inorganic Chemistry. 8. S. Shanmugam, Nanotechnology, MJP Publishers, Chennai. 9. Patrick Salomon, A Handbook on Nanochemistry, Dominant Publishers and Distributers, New Delhi. 10. S. Balaji, Nanobiotechnology, MJP Publishers, Chennai.

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<table>
<tr><th colspan="4">M.Sc. Semester –III</th></tr>
<tr><th colspan="4">PAPER – IV(Elective)</th></tr>
<tr><td>COURSE CODE:
CHE3TH14</td><td>SPECTROSCOPY OF ORGANIC COMPOUNDS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of NMR spectroscopy (^{1}H and ^{13}C), including spectral interpretation, coupling phenomena, advanced techniques, and their application in structural analysis of organic compounds.
2. To develop understanding of mass spectrometry, including ionization methods, fragmentation patterns, and spectral interpretation for molecular structure determination.
3. To enable students to apply combined spectroscopic techniques (UV, IR, NMR, and Mass spectrometry) for accurate identification and structural elucidation of organic molecules.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Exhibit a thorough understanding of Nuclear Magnetic Resonance (NMR) spectroscopy and apply it to interpret complex spectra and determine molecular structures.
2. Utilize advanced NMR concepts, including virtual coupling, stereochemical effects, and the Karplus relationship, for accurate interpretation of spectral data.
3. Analyse Carbon-13 NMR spectra by evaluating chemical shifts, coupling patterns, and specialized techniques such as DEPT, INEPT, and APT, and apply two-dimensional NMR methods for detailed structural elucidation.
4. Explain the fundamental principles and applications of Mass Spectrometry and use mass spectral data to identify and confirm the structures of organic molecules.
5. Integrate information obtained from UV, IR, ^{1}H NMR, ^{13}C NMR, and Mass Spectrometry to systematically determine the structures of organic compounds.</td></tr>
</table>

Syllabus	**UNIT-I** **Nuclear Magnetic Resonance Spectroscopy I**: PMR Spectroscopy chemical exchange, effect of deuteration, complex spin-spin interaction between two, three four and five nuclei (first order spectra). **UNIT-II** **Nuclear Magnetic Resonance Spectroscopy II**: Virtual coupling, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplication of complex spectra-nuclear magnetic double resonance, contract shift reagents, solvent effects. Fourier transform technique, Nuclear Overhauser Effect (NOE)-NOESY. Resonance of other nuclei: F, P, N. Structural problems based on PMR. **UNIT-III** **Nuclear Magnetic Resonance Spectroscopy III**: Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Off- resonance decoupling, DEPT, INEPT, APT techniques. Two- dimension, NMR spectroscopy: COSY, HMBC and INADEQUATE techniques. Structural problem based on ^{13}C NMR. **UNIT-IV** **Mass Spectrometry**: Introduction, ion production-EI, CI, FAB, ESI, APCI, MALDI, factors affecting fragmentation, ion analysis, ion abundance, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Isotopic peaks. Mc-Lafferty rearrangement, Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect of their structure determination. **UNIT-V** Structural problems by joint application of UV, IR, NMR (^{1}H & ^{13}C) and mass spectroscopy.
Recommended Books	1. Organic Spectroscopy, Prof L. D. S. Yadva, Springer (2005). 2. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Brooks Cole, 5th Ed., 2015.

	3. R.M. Silverstein, F. X. Webster, Spectrometric Identification of Organic compounds, John Wiley & Sons Inc., 7th Ed., 2011. 4. D.H Williams & I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata Mcgraw Hill Education, 6th Ed., 2011. 5. W. Kemp, Organic Spectroscopy, Palgrave Macmillan, 3rd Ed., 1991. 6. L. D. Field, H. L. Li., A. M. Magill, Organic Structures from 2D NMR Spectra, Wiley, 2015. 7. L. D. Field, S. Sternhell and J R Kalman, Organic Structures from spectra; John Wiley & Sons Ltd., 2007.

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<table>
<tr><th colspan="4">M.Sc. Semester – IV (INORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td>COURSE CODE:
CHE4TH01</td><td>ADVANCED SPECTROSCOPIC TECHNIQUES IN CHEMICAL ANALYSIS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. Provide in-depth understanding of advanced spectroscopic techniques used in chemical analysis and structural elucidation.
2. Develop theoretical and practical knowledge of ^{1}H and ^{13}C NMR spectroscopy including chemical shifts, spin–spin coupling, relaxation mechanisms, NOE, DEPT, dynamic NMR, and paramagnetic effects.
3. Introduce multinuclear NMR spectroscopy (^{19}F, ^{31}P, ^{77}Se, ^{107}Ag, ^{195}Pt, ^{119}Sn, ^{11}B) and their applications in organic, inorganic, and coordination chemistry.
4. Explain the principles of EPR spectroscopy and its application in studying paramagnetic species and transition metal complexes.
5. Develop conceptual clarity in vibrational spectroscopy (IR and Raman), including selection rules, symmetry considerations, metal–ligand bonding, and structural determination.
6. Provide comprehensive knowledge of modern mass spectrometry including ionization methods, mass analyzers, isotopic pattern analysis, and fragmentation mechanisms.
7. Enable students to integrate multiple spectroscopic techniques for accurate molecular structure determination.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">Upon successful completion of the course, students will be able to:
1. Explain the principles of NMR spectroscopy and interpret ^{1}H and ^{13}C NMR spectra including coupling patterns, relaxation processes, NOE, DEPT spectra, dynamic exchange phenomena, and paramagnetic effects.
2. Analyze multinuclear NMR spectra and correlate chemical shifts and coupling behavior with molecular structure and electronic environment.</td></tr>
</table>

	3. Interpret EPR spectra of paramagnetic systems by evaluating g-values, hyperfine splitting, zero-field splitting, and anisotropic effects in transition metal complexes. 4. Apply IR and Raman selection rules to identify vibrational modes, determine functional groups, and establish bonding modes in coordination compounds. 5. Use combined IR and Raman spectral data to determine molecular geometry of AB_2, AB_3, and AB_4 type molecules using symmetry principles and the rule of mutual exclusion. 6. Explain different ionization techniques (EI, CI, FAB, ESI), mass analyzers (magnetic sector, TOF, quadrupole), and detectors used in mass spectrometry. 7. Interpret isotopic patterns, calculate isotopic distributions using the binomial approach, and analyze [M+1] and [M+2] peaks. 8. Apply nitrogen rule, rule of thirteen, even-electron rule, Stevenson's rule, McLafferty rearrangement, and HDI/DBE calculations for structural elucidation. 9. Integrate data from NMR, EPR, IR, Raman, and Mass spectrometry for comprehensive structural characterization of organic, inorganic, and organometallic compounds.
Syllabus	**UNIT- I (NMR Spectroscopy)** NMR spectroscopy: basic principles; Chemical environment and chemical shifts; Coupling constant: mechanism of coupling, one, two, three and long range coupling; Molecular relaxation processes; Double resonance; Decoupling phenomenon; Cross polarization-NOE; Off resonance; DEPT spectra and its structural applications in ^{13}CNMR; Use of chemicals as NMR auxiliary reagents (shift and relaxation reagents); Dynamic processes in NMR: NMR due to proton exchange- (i) proton on oxygen-alcohols (ii) proton on nitrogen-amines (iii) solvent effect; 1H NMR of paramagnetic substances. **UNIT-II (Multinuclei NMR)** NMR spectroscopy of the multinuclei: ^{19}F, ^{31}P, ^{77}Se, ^{107}Ag, ^{195}Pt, ^{119}Sn, and ^{11}B. **UNIT- III (EPR Spectroscopy)** Electron spin resonance spectroscopy: basic principle, hyperfine splitting (isotropic systems); g value and the factors affecting the g value; Interactions affecting electron energies in paramagnetic complexes (Zero-field splitting

	and Kramer's degeneracy); Electron-electron interactions, Anisotropic effects (the g value and the hyperfine couplings); Structural applications to transition metal complexes. **UNIT IV (IR and Raman Spectroscopy)** **Infrared spectroscopy:** basic principle, selection rule for harmonic and anharmonic oscillator, fundamental vibrations, overtones and combination frequencies; Functional group vibrations; Factors affecting CO, CN, NO, NO_2 stretching frequencies in their corresponding transition metal complexes; Mode of bonding of ambidentate ligands. **Raman spectroscopy:** Rayleigh scattering, Raman scattering (Stokes and Anti-Stokes line); Classical and quantum theory of Raman effect; Raman activity of vibration for H_2O and CO_2 molecules; Rule of mutual exclusion; Combined use of Raman and infra-red spectroscopy to determine the shapes of simple AB_2, AB_3, and AB_4 molecules. **UNIT- V (Mass Spectrometry)** Mass spectrometry: basic principle and measurement of m/z; Various types of ions; Ionization techniques: electron ionization, chemical ionization, fast atom bombardment, and electrospray ionization (ESI); Charge deconvolution in ESI; Mass analyzers: magnetic sector (single focusing), time of flight, quadrupole mass analyzer; Detectors: Faraday cup and electron multiplier; Different types of masses; [M+1] and [M+2] masses; Isotopes and its natural abundance and pattern in mass spectrum; Calculation of isotopic distributions (binomial approach); Mass accuracy; Resolution and high resolution mass spectrometry (HRMS); Nitrogen rule; Rule of thirteen; Even-electron rule; Hydrogen density index (HDI) or double bond equivalence (DBE); Stevenson's rule; McLafferty rearrangement; Fragmentation in mass spectrometry.
Recommended Books	1. D. L. Pavia, G. M. Lampman, G. S. Kriz, and J. R. Vyvyan, Introduction to Spectroscopy. 2. C. N. Banwel and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw- Hill Publishing Company Limited. 3. K. Das and M. Das, Fundamental Concepts of Inorganic chemistry, Volume 7, CBS Publishers and Distributors Pvt. Ltd.

	4. H. H. Willard, L. L. Merritt, J. A. Dean, and F. A. Settle, Instrumental Methods of Analysis. 5. D. A. Skoog, F. J. Holler, and S. R. Crouch, Instrumental Analysis. 6. J. Mendham, R. C. denney, J. D. Barnes, M. Thomas, and B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis. 7. Jurgen H. Cross, Mass Spectrometry: A Text Book. 8. Edmond de Hoffmann and Vincent Stroobant, Mass Spectrometry: Principles and Applications.

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<table>
<tr><th colspan="4">M.Sc. Semester – IV (INORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – II</th></tr>
<tr><td>COURSE CODE:
CHE4TH02</td><td>STRUCTURAL METHODS IN INORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To understand magnetic properties of transition metal complexes including spin crossover and metal–metal exchange interactions.
2. To study modern electron spectroscopic techniques such as XPS, AES, and UPS for structural determination of inorganic compounds.
3. To develop knowledge of X-ray based techniques including XRD, SAXS, XAS, EXAFS, XANES, and XRF for structural and compositional analysis.
4. To understand UV-Visible spectroscopy and electronic transitions in coordination complexes.
5. To study Mössbauer spectroscopy and Nuclear Quadrupole Resonance (NQR) for structural and electronic characterization.
6. To integrate magnetic and spectroscopic techniques for advanced structural elucidation of inorganic systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Explain magnetic behavior of transition metal complexes including single molecule magnets, spin crossover phenomena, and binuclear exchange interactions using the Bleaney–Bower equation.
2. Apply modern magnetic susceptibility measurement techniques to interpret anomalous magnetic properties.
3. Interpret XPS, AES, and UPS spectra including chemical shifts and depth profiling for structural and catalytic applications.
4. Analyze X-ray diffraction and absorption techniques such as XRD, EXAFS, XANES, SAXS, and XRF for structural determination.
5. Assign electronic transitions in UV-Visible spectra of octahedral transition metal complexes using selection rules.
6. Interpret Mössbauer spectral parameters such as isomer shift, quadrupole splitting, and magnetic interactions for structural deductions.</td></tr>
</table>

	7. Explain the theoretical principles and applications of Nuclear Quadrupole Resonance (NQR). 8. Correlate magnetic and spectroscopic data to determine structure, bonding, and electronic properties of inorganic complexes.
Syllabus	**UNIT- I (Magnetic Properties)** Magnetic properties; Magnetic behaviors: single molecule magnet and single chain magnet; Recent methods of magnetic susceptibility measurements; Anomalous magnetic properties of transition metal complexes; Spin cross-over phenomena; Magnetic properties of binuclear metal complexes involving metal-metal exchange interaction (Bleaney-Bower equation). **UNIT- II (Electron Spectroscopy)** X-ray photoelectron spectroscopy (XPS); Aauger electron spectroscopy (AES); Ultraviolet photoelectron spectroscopy (UPS): instrumentation, basic principles, spectral features, chemical shifts, depth profiling and its utilization to structure determination of inorganic molecules and metal complexes leading to their implementation in catalysis. **UNIT- III (X-ray Spectroscopy)** X-Ray spectroscopy: X-ray sources, scattering and absorption, refraction and reflection from interfaces, refractive index, X-ray optics, scattering from non-crystalline material, small angle X-ray scattering (SAXS); Scattering from crystalline material: X-ray diffraction (XRD), X-ray absorption spectroscopy (XAS), X-ray absorption fine structure spectroscopy (EXAFS), X-ray absorption near edge spectroscopy (XANES) with synchrotron radiation techniques, X-ray fluorescence (XRF), emission spectroscopy, scanning X-ray fluorescence spectroscopy (XRF), X-ray detectors, X-ray imaging: scanning transmission, tomography. **UNIT- IV (UV Visible Spectroscopy)** UV Visible Spectroscopy: basic principle and instrumentation; Type of transitions: charge transfer spectra, d-d transition; Selection rules; Electronic spectra of complexes: $[V(H_2O)_6]^{3+}$, $[Cr(H_2O)_6]^{3+}$, $[Cr(H_2O)_6]^{2+}$, $[Mn(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{2+}$, $[Co(H_2O)_6]^{2+}$, $[Ni(H_2O)_6]^{2+}$ and $[Cu(H_2O)_6]^{2+}$. **UNIT- V (Mossbauer Spectroscopy)** Mossbauer Spectroscopy: basic principle; Conditions for Mossbauer spectroscopy; Spectral parameters: isomer shift, electric quadrupole interactions, magnetic interactions; Structural deductions for important

	complexes.Nuclear Quadrupole Resonance (NQR): Theory and its applications.
Recommended Books	**Recommended Books** 1. R. L. Dutta and G. S. De, Inorganic Chemistry Part I, The New Book Stall 2. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley and Sons, 2008. 3. S. Zhang, Lin Li, and A. Kumar, Materials Characterization Techniques, CRC press, 2008. 4. Jeroen A. Van Bokhoven, X-Ray Absorption and X-Ray Emission Spectroscopy, John Wiley and Sons, Ltd, 2016. 5. Introduction to XAFS, Cambridge University Press, 2011. 6. H. H. Willard, L. L. Merritt, J. A. Dean, and F. A. Settle, Instrumental Methods of Analysis. 7. D. A. Skoog, F. J. Holler, and S. R. Crouch, Instrumental Analysis. 8. J. Mendham, R. C. denney, J. D. Barnes, M. Thomas, and B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis. 9. Leopold May, An Introduction to Mossbauer Spectroscopy.

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<table>
<tr><th colspan="3">M.Sc. Semester – IV (INORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="3">PAPER – III</th></tr>
<tr><td rowspan="2">COURSE CODE:
CHE4TH03</td><td rowspan="2">SELECTED TOPICS IN INORGANIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="2">1. To understand the principles and working mechanisms of electron microscopy techniques including SEM and TEM.
2. To study scanning probe microscopy techniques such as AFM and STM and their surface characterization applications.
3. To develop knowledge of photochemical processes in metal complexes including excited states and photoreactions.
4. To understand electrochemical techniques such as cyclic voltammetry and their analytical applications.
5. To learn advanced voltametric and coulometric techniques for quantitative and mechanistic studies.
6. To integrate microscopic, photochemical, and electrochemical methods for advanced materials and coordination chemistry research.</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">After successful completion of this course, students will be able to:
1. Explain the historical development and fundamental principles of electron microscopy and differentiate between light microscopy, SEM, and TEM.
2. Describe electron beam–sample interactions and sample preparation techniques for SEM and TEM analysis.
3. Explain the working principles of AFM and STM including probe-sample interactions, tunneling phenomenon, and different operational modes.
4. Interpret photochemical processes in metal complexes including singlet and triplet states, quantum yield, excimers, and photoreactions of transition metal systems.
5. Analyze cyclic voltammetry curves and interpret redox behavior of systems such as $K_3Fe(CN)_6$ and $LiFePO_4$.</td></tr>
</table>

	6. Differentiate various voltametric techniques including differential pulse voltammetry, anodic stripping voltammetry, and chronoamperometry with their applications. 7. Explain the principles, types, instrumentation, and applications of coulometry. 8. Apply microscopic, photochemical, and electrochemical techniques for structural, mechanistic, and catalytic investigations in chemical research.
Syllabus	**UNIT- I (Electron Microscopy)** Electron microscopy: Historical overview of electron microscopy; Comparison between light microscopy and electron microscopy; Scanning Electron Microscopy (SEM): Working principles; Electron beam-sample interactions; Sample preparation techniques for SEM; Transmission Electron Microscopy (TEM): Introduction to TEM; Electron diffraction and imaging. **UNIT- II (Microscopic Techniques)** Overview of microscopy techniques, Basic principles of scanning probe microscopy, Comparison between AFM and STM, Atomic force microscopy (AFM): Working principles of AFM; Modes of operation: contact mode, tapping mode, non-contact mode; Probe-sample interactions; Surface tunneling microscopy (STM): Introduction to STM; Quantum tunneling phenomenon; Tunneling current and tip-sample interactions. **UNIT – III (Photochemistry)** Principles of photochemistry in metal complexes (electronic excitation, singlet, and triplet states, Franck-Condon principle, excimers, and exciplexes, quantum yields, and reactions of excited states). Photoreactions of first-row transition metals like chromium(III), cobalt(III), copper(I)/(II), and manganese-based photosystems. Photoreactions of dimeric, multimetallic complexes, and various reactions involving $Ru(bpy)^{3+}$ and related complexes, including catalytic processes and chemiluminescence. **UNIT- IV (Cyclic Voltammetry-I)** Linear sweep voltammetry and cyclic voltammetry: Working principle and its application; Instrumentation; Analysis of Cyclic voltammetry curve for $K_3Fe(CN)_6$ and $LiFePO_4$.

	UNIT- V (Cyclic Voltammetry-II) Types of voltammetry: Differential pulse voltammetry (principle and application), anodic stripping voltammetry (principle and application), chronoamperometry (principle and application), Coulometry: working principle; Types of Coulometry, Instrumentation and Application.
Recommended Books	1. R.F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AFM. 2. Brent Fultz and James M. Howe, Transmission Electron Microscopy and Diffractometry of Materials. 3. D. M. Roundhill, Photochemistry and Photophysics of Metal Complexes. 4. Philip H. Rieger, Electrochemistry, Brown University, 1986, ISBN No: 0-13-249138-9. 5. Valentin Mirceski, Sebojka Komorsky-Lovric, and Milivoj Lovric, Theory and Application: Square-Wave Voltammetry, 2007, ISBN: 9783540737407.

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<table>
<tr><td colspan="4">M.Sc. Semester –IV (ORGANIC CHEMISTRY SPECIALIZATION)</td></tr>
<tr><td colspan="4">PAPER – IV (ELECTIVE)</td></tr>
<tr><td rowspan="2">COURSE CODE:
CHE4TH14</td><td rowspan="2">REAGENTS AND REACTIONS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of important reagents used in organic synthesis and their applications in functional group transformations with emphasis on selectivity and stereochemistry.
2. To develop understanding of selective organic reactions, modern synthetic methods, and their mechanistic aspects for efficient construction of organic molecules.
3. To impart knowledge of green chemistry principles and environmentally benign synthetic protocols, including modern name reactions and sustainable approaches in organic synthesis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Develop an understanding of the use of modern synthetic reactions and reagents in organic synthesis.
2. Acquire the knowledge and skills required to use a broad range of reagents in organic synthesis, understand stereochemical aspects of chemical transformations, and carry out selective organic reactions.
3. Develop an understanding of green chemistry principles to promote sustainable synthetic practices and environmentally friendly organic reactions.
4. Become familiar with atom-economical named organic reactions and their applications in chemical synthesis.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT- I

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible) Complex metal hydrides – $NaBH_4$, Sodium cyanoborohydride, $LiAlH_4$ (LAH), Alkoxy substituted LAH, DIBAL, diborane, Selectride, diisoamylborne, thexylborane, 9-BBN, isopinocamphenyl and diisopino-campherylborame, catechoborane Gilman’s reagent, Lithium disopropyl amide (LDA).</td></tr>
</table>

	UNIT- II Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): Dicyclohexylcarbcarbodimide (DCC), DEAD, 1, 3-Dithiane (Reactivity Umpolung), Trimethylsily iodide, Tri n-butyltin hydride, PCC. **UNIT- III** Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): DDQ & SeO_2, Hydrazine, phenylhydrazine & p-Toluenesulfonyl hydrazide, nucleophilicheterocyclic carbenes (NHC), Nitrogen, Sulphur and Phosphorus Ylides-preparation and their synthetic applications. **UNIT-IV** Selective Organic Reaction and their Synthetic Application: Stork Enamine reaction, Ene and related reactions, Reaction at inactivated C-H bonds- Barton Reaction & Hofmann-Loffler- Freytag reaction. Olefine Ring Closing Metathesis. **UNIT- V** Green Chemistry: Introduction of green chemistry basic principles of green chemistry, Green protocol for benzoin condensation, bromination and acylation, organic synthesis using visible light and ionic liquid. Selective Organic name reaction and their Synthetic Application in reference to Green Chemistry: Baylis-Hillman Reaction, Stetter Reaction, Passerinin and Ugi Reactions.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002. 2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 3. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 4. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 5. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004). 6. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge

	University Press (1996). 7. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 8. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 9. P. T. Anastas and T. C. Williamson, Green Chemistry: Frontiers in benign chemical synthesis and processes, Oxford University Press, Oxford, Ed. 1998. 10. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.

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<table>
<tr><th colspan="4">M.Sc. Semester –III (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td>COURSE CODE:
CHE3TH04</td><td>REARRANGEMENTS AND PHOTOCHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="3">To provide students with a comprehensive understanding of molecular rearrangement reactions and organic photochemistry, including their mechanisms, reaction pathways, and synthetic applications, enabling them to predict reaction outcomes and apply photochemical and rearrangement processes in organic synthesis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Develop a comprehensive understanding of the fundamental principles of molecular rearrangements, including their detailed reaction mechanisms
2. Acquire knowledge of the role and applications of molecular rearrangements in modern organic synthesis.
3. Understand the fundamental concepts of organic photochemistry, including key processes, excited-state phenomena, and associated terminology.
4. Gain insight into the photochemical behaviour and reaction mechanisms of different classes of organic compounds, such as olefins, carbonyl compounds, and aromatic systems.
5. Develop an understanding of the practical applications of organic photochemistry in synthesis, materials science, and related fields.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT-I

Molecular Rearrangements I: Migration to electron deficient carbon atom-Pinacole- Pinacolone rearrangement, Wagner-Meerwein rearrangement, Tiffeneau-Demjanov ring expansion, Dienone-Phenol rearrangement, Wolf rearrangement, Benzil-benzilic acid rearrangement, Favorski rearrangement, Wittig rearrangement.

UNIT-II

Molecular Rearrangements II: Migration to electron deficient nitrogen atom-Hofmann, Curtius, Losen, Schmidt, Beckmann rearrangement.</td></tr>
</table>

	Migration to electron deficient oxygen atom- Baeyer-Villiger rearrangement, Hydroperoxide rearrangement, Dakin reaction. Miscellaneous: Nazarov rearrangement **UNIT-III** **Photochemistry I**: Absorption of light by organic molecules, properties of excited states, mechanism of excited state processes and methods of preparative photochemistry, Photochemistry of Carbonyl Compounds: cleavage reaction, addition reaction, reduction & oxidation, hydrogen abstraction. **UNIT-IV** **Photochemistry II**: Rearrangements of ketones, dienone, α, ß - unsaturated ketones and cyclohexadienones, **UNIT-V** **Photochemistry III: Photochemistry of unsaturated system** Olefins, cis-trans isomerisation, dimerisation, and additions. Dienes-photochemistry of 1, 3-butadiene (2+2) additions leading to cage structures, photochemistry of cyclohexadienes, Photochemistry of aromatic compounds-exited state of benzene and its 1,2 and 1, 3-shifts, Photo-Fries rearrangement, Photo-Fries reaction of anilides, photosubstitution reaction of benzene derivatives.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004). 5. N. J. Turro, J. C. Scaiano, and V. Ramamurthy, Modern Molecular Photochemistry of Organic Molecules, University Science Books, 2010. 6. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi. 7. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge

	University Press (1996). 8. Horspool, W. M. *Aspects of Organic Photochemistry* Academic Press (1976). 9. Photochemistry and Pericyclic Reactions, by Prof Jagdamba Singh and Dr. J. Singh,

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<table>
<tr><th colspan="4">M.Sc. Semester- III (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><td colspan="4">PAPER – II</td></tr>
<tr><td>COURSE CODE:
CHE3TH05</td><td>OXIDATION, REDUCTION, AND ORGANOMETALLIC-REAGENTS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To develop a thorough understanding of oxidation and reduction reactions of organic compounds and the role of organometallic reagents, including their mechanisms, selectivity, stereochemistry, and applications in modern organic synthesis, enabling students to apply these transformations in the design and synthesis of complex organic molecules.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Develop a thorough understanding of the fundamental principles of oxidation and reduction reactions, including their detailed mechanistic pathways.
2. Acquire knowledge of the applications and selection of various oxidizing and reducing agents in organic synthesis.
3. Understand the fundamental concepts, structure, and reactivity of organometallic reagents employed in organic synthesis.
4. Gain knowledge of various palladium-catalysed coupling reactions and their significance in modern organic synthesis.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT-I
Oxidation I: Oxidation of Hydrocarbons-alkenes-including oxidative functionalization, aromatic rings, saturated, C-H groups (activated and un activated), alcohols, diols.
UNIT- II
Oxidation II: Oxidation of Aldehydes, ketones and carboxylic acids, amines, hydrazines and sulphides. Oxidations with ruthenium tetraoxide, iodobenzene diacetate and thallium (III) nitrate.
UNIT-III
Reduction: Reduction of Hydrocarbons–alkenes, alkynes and aromatic rings, Carbonyl Compounds: aldehydes, ketones, acids and their derivatives, Epoxides, nitro, nitroso, azo compounds, Hydrogenolysis,</td></tr>
</table>

	UNIT-IV **Organometallic Reagents I**: Prominent Synthetic applications of organometallic compounds with mechanistic and stereochemical details of following metals-Hg, Cd, Ce, Zn, In, Ni, Fe, Co, Rh, Cr, Ru and Ti. **UNIT- V** **Organometallic Reagents II**: Application of Pd(o) and Pd(II) complexes in organic synthesis – Stille, Suzuki and Sonogashira coupling, Heck reaction and Negishi coupling and their stereochemistry
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004). 5. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996). 6. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 7. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 8. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav. 9. P. R. Jenkins, Organometallic Reagents in Synthesis, Oxford science Publ., Oxford (1992).

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<table>
<tr><th colspan="4">M.Sc. Semester –III (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – III</th></tr>
<tr><td rowspan="2">COURSE CODE:
CHE3TH06</td><td rowspan="2">STRATEGIES IN ORGANIC SYNTHESIS AND HETEROCYCLIC CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To develop the ability to apply retrosynthetic analysis, disconnection approach, and functional group interconversions for the systematic design of organic synthesis.
2. To provide knowledge of synthetic strategies, protecting groups, and multistep synthesis for the efficient construction of complex organic molecules.
3. To impart understanding of heterocyclic chemistry, including nomenclature, synthesis, reactivity, and applications of important heterocyclic compounds in organic synthesis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Develop the ability to independently design and present efficient synthetic routes for the preparation of organic molecule
2. Understand and explain the concepts of umpolung, synthons, synthetic equivalents, and stereo control, and apply them effectively in planning organic syntheses.
3. Describe the fundamental principles of retrosynthetic analysis and utilize them to design logical and efficient synthetic strategies.
4. Develop appropriate protecting group strategies and understand their role and application in the synthesis of complex organic molecules.
5. Demonstrate proficiency in the nomenclature, reactivity, and synthetic methodologies of various heterocyclic compounds</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT-I
Disconnection Approach: General introduction to synthons and Synthetic equivalents, Disconnections, (C-C, C- S, C-O, C-N bonds).</td></tr>
</table>

	UNIT-II **Functional group interconversion**: chemo selectivity, Umpolung, cyclisation reaction choosing synthetic route for small- and large-scale synthesis. **UNIT-III** **Synthetic Strategies:** (i). For formation of carbon-carbon bond. (ii). For formation of carbon- nitrogen bond. (iii). For formation of carbon-halogen bond. (iv). For Ring Synthesis (v). For Multistep Synthesis e.g. Complex molecules- Camphor, Reserpine and Vitamin D. **UNIT-IV** **Protecting Groups**: The Concept of Protecting Functional Groups: protection of alcoholic, amino, carbonyl and carboxylic groups. **UNIT-V** **Heterocyclic Chemistry**: General Introduction, Nomenclature (including fused heterocycles), spectral characteristics, reactivity and aromaticity. Synthesis and reactivity of pyrazole, imidazole, oxazole, thiazole, isooxazole and their applications in organic synthesis.
Recommended Books	1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 3. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004). 4. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996). 5. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 6. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 7. A. R. Katritzky and A. F. Pozharskii, Handbook of Heterocyclic Chemistry, Elservier, 2000. 8. J. A. Joule, K. Mills, G. F. Smith, Heterocyclic chemistry, 3rd Edition, Stanley Thornes Publishers Ltd, 1995. 9. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 10. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.

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<table>
<tr><th colspan="4">M.Sc. Semester –III</th></tr>
<tr><th colspan="4">PAPER – IV(Elective)</th></tr>
<tr><td>COURSE CODE:
CHE3TH14</td><td>SPECTROSCOPY OF ORGANIC COMPOUNDS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of NMR spectroscopy (^{1}H and ^{13}C), including spectral interpretation, coupling phenomena, advanced techniques, and their application in structural analysis of organic compounds.
2. To develop understanding of mass spectrometry, including ionization methods, fragmentation patterns, and spectral interpretation for molecular structure determination.
3. To enable students to apply combined spectroscopic techniques (UV, IR, NMR, and Mass spectrometry) for accurate identification and structural elucidation of organic molecules.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Exhibit a thorough understanding of Nuclear Magnetic Resonance (NMR) spectroscopy and apply it to interpret complex spectra and determine molecular structures.
2. Utilize advanced NMR concepts, including virtual coupling, stereochemical effects, and the Karplus relationship, for accurate interpretation of spectral data.
3. Analyse Carbon-13 NMR spectra by evaluating chemical shifts, coupling patterns, and specialized techniques such as DEPT, INEPT, and APT, and apply two-dimensional NMR methods for detailed structural elucidation.
4. Explain the fundamental principles and applications of Mass Spectrometry and use mass spectral data to identify and confirm the structures of organic molecules.
5. Integrate information obtained from UV, IR, ^{1}H NMR, ^{13}C NMR, and Mass Spectrometry to systematically determine the structures of organic compounds.</td></tr>
</table>

Syllabus	**UNIT-I** **Nuclear Magnetic Resonance Spectroscopy I**: PMR Spectroscopy chemical exchange, effect of deuteration, complex spin-spin interaction between two, three four and five nuclei (first order spectra). **UNIT-II** **Nuclear Magnetic Resonance Spectroscopy II**: Virtual coupling, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplication of complex spectra-nuclear magnetic double resonance, contract shift reagents, solvent effects. Fourier transform technique, Nuclear Overhauser Effect (NOE)-NOESY. Resonance of other nuclei: F, P, N. Structural problems based on PMR. **UNIT-III** **Nuclear Magnetic Resonance Spectroscopy III**: Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Off- resonance decoupling, DEPT, INEPT, APT techniques. Two- dimension, NMR spectroscopy: COSY, HMBC and INADEQUATE techniques. Structural problem based on ^{13}C NMR. **UNIT-IV** **Mass Spectrometry**: Introduction, ion production-EI, CI, FAB, ESI, APCI, MALDI, factors affecting fragmentation, ion analysis, ion abundance, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Isotopic peaks. Mc-Lafferty rearrangement, Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect of their structure determination. **UNIT-V** Structural problems by joint application of UV, IR, NMR (^{1}H & ^{13}C) and mass spectroscopy.
Recommended Books	1. Organic Spectroscopy, Prof L. D. S. Yadva, Springer (2005). 2. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Brooks Cole, 5th Ed., 2015.

	3. R.M. Silverstein, F. X. Webster, Spectrometric Identification of Organic compounds, John Wiley & Sons Inc., 7th Ed., 2011. 4. D.H Williams & I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata Mcgraw Hill Education, 6th Ed., 2011. 5. W. Kemp, Organic Spectroscopy, Palgrave Macmillan, 3rd Ed., 1991. 6. L. D. Field, H. L. Li., A. M. Magill, Organic Structures from 2D NMR Spectra, Wiley, 2015. 7. L. D. Field, S. Sternhell and J R Kalman, Organic Structures from spectra; John Wiley & Sons Ltd., 2007.

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DEPARTMENT OF CHEMISTRY

<table>
<tr><th colspan="4">M.Sc. Semester –IV (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><td colspan="4">PAPER – I</td></tr>
<tr><td>COURSE CODE:
CHE4TH04</td><td>BIOSYNTHESIS AND CHEMISTRY OF NATURAL PRODUCTS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of the biosynthesis, classification, structure, and stereochemistry of important natural products such as terpenoids, alkaloids, steroids, prostaglandins, and plant pigments.
2. To develop understanding of biosynthetic pathways including acetate, mevalonate, and shikimic acid pathways involved in the formation of biologically important natural compounds.
3. To enable students to apply chemical and spectroscopic methods for structure elucidation and synthesis of natural products and understand their significance in biological and medicinal chemistry.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">1. Gain knowledge of the classification systems and significance of different natural products such as terpenes, steroids, alkaloids, polyphenols, plant pigments, and prostaglandins.
2. Acquire an understanding of the complete chemical synthesis of natural products as well as their biological biosynthetic pathways.
3. Develop competence in the preparation and characterization of natural products that are frequently encountered in everyday life.
4. Build the ability to predict and determine the structural elucidation pathways of unknown naturally occurring organic molecules.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT- I

Bio-synthesis of Natural Products:

The acetate hypothesis, poly β-Ketoacids, Biosynthesis, Biogenesis Primary and Secondary reactions involved in biosynthesis. Biosynthesis of poly-ß-ketoacid. Isoprene rule, mevalonic acid from acetyl Co-enzyme A. Biosynthesis of mono, sesqui, di and triterpenes. Shikimic acid pathway for biosynthesis of aromatic ring. General biosynthesis of alkaloids.</td></tr>
</table>

	UNIT- II **Terpenoids and Carotenoids:** Classification, isoprene rule. Structure determination, stereochemistry, synthesis of the following representative molecules: citral, α-terpenol, menthol, farnesol, abiatic acid and ß-carotene. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible. Introduction of Camphor and α-pinene. **UNIT- III** **Alkaloids:** Classification, General methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, Structure, stereochemistry and synthesis of the following: Ephedrine, (+) nicotine, quinine and morphine. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible. **UNIT- IV** **Steroids**: Basic skeleton Diel's hydrocarbon and stereochemistry, structure determination and synthesis of cholesterol, testosterone, estrone and progesterone. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible. Introduction of Adrenal cortitial hormones **UNIT- V** **Prostaglandins**: Occurrence, nomenclature, classification. Synthesis of PGE_2 and PGF_{2a} **Plant Pigments**: General methods of structure determination, synthesis of Apigenin, Quercetin Cyanidin, Hirsutin. Quercetin-3-glucoside, Diazein and cyanidine-7-glucoside. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 2. Mann, J. Secondary Metabolites, Oxford University Press, Oxford, UK, (1980). 3. K. Nakanishi, Natural Product Chemistry, Academic Press, 2013. 4. D. R. Dalton, The Alkaloids. New York: M. Dekker, 1979. 5. Barton and Olis, Comprehensive Organic Chemistry, Pergamon, 1979. 6. D. Paul, Medicinal Natural Products: A Biosynthetic Approach, John Wiley and Sons, 2002. 7. M. Paolo, Biosynthesis of Natural Products, Wiley, 2010. 8. Jagdamba Singh, S. M. Ali & J. Singh, Natural Products Chemistry, Pragati Prakashan.

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<table>
<tr><th colspan="4">M.Sc. Semester –IV (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><td colspan="4">PAPER – II</td></tr>
<tr><td rowspan="2">COURSE CODE:
CHE4TH05</td><td rowspan="2">STEREOSELECTIVE SYNTHESIS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide fundamental understanding of stereoselectivity, stereospecificity, and regioselectivity in organic reactions, particularly in cyclic and conformationally constrained systems.
2. To develop knowledge of diastereoselective and asymmetric synthesis, including the use of chiral substrates, auxiliaries, reagents, and stereochemical models to control reaction outcomes.
3. To impart understanding of the stereochemical aspects and mechanisms of important organic reactions and their applications in the synthesis of stereo chemically defined molecules.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Explain the concepts of stereoselectivity, stereospecificity, regioselectivity, and conformational control in cyclic and polycyclic compounds.
2. Apply stereochemical models such as Cram’s rule, Felkin–Anh model, and chelation control to predict the stereochemical outcome of nucleophilic additions to chiral carbonyl compounds.
3. Demonstrate understanding of asymmetric synthesis using chiral pool, chiral auxiliaries, and chiral reagents for the preparation of enantiomerically enriched compounds.
4. Analyse the stereochemical mechanisms and outcomes of important organic reactions such as Mitsunobu reaction, Sharpless epoxidation, and conjugate additions.
5. Apply stereochemical principles to predict and interpret the stereochemical outcome of advanced synthetic reactions including olefination, fragmentation, and radical cyclization reactions.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT- I
Stereoselective reactions of cyclic compounds: Introduction:
Stereoselectivity and stereospecificity. Regioselectivity and regiospecificity.</td></tr>
</table>

	Reactions of four, five and six-membered rings including bicyclic, fused & spirocyclic compounds-conformational control & stereoselectivity. Stereoselective reactions via formation of cyclic intermediate/transition state. **UNIT- II** **Diastereoselective:** π- facial addition of nucleophilic to chiral carbonyl compounds: Chiral substrate with α-stereocentres- Crams model, Felkin-Ann model, Crams Chelate model, Prelog's rule. Addition of nucleophilic to chiral carbonyl compounds Chiral substrate with β - stereocentres. **UNIT- III** **Asymmetric Synthesis I:** The principle of asymmetric synthesis. Asymmetric synthesis using: Chiral pool (ii). Chiral auxiliary: Oxazolidinone, Proline-based chiral auxiliary, controlled Diels-Alder reaction, alkylation of chiral enolates and aldol reaction. Alkylation using SAMP and RAMP. (iii) Chiral reagents **UNIT- IV** **Stereochemistry of some reaction** (i) Conjugate addition with R_2CuLi, (ii) Mitsunobu reaction (iii) Addition of bromine and peroxide on cyclohexene (iv) Sharpless asymmetric epoxidation (v) Conjugate addition use of imidazolidinones **UNIT- V** **Stereochemistry of some reaction**: (i). Mc-Marry reaction. (ii). Corey-Winter reaction. (iii). Fragmentation reaction. (iv). Julia olefination (v) Diastereoselective radical cyclization reactions.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).

	5. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996). 6. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 7. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 8. Stereochemistry with applications to organic reactions by Prof. J. Singh, Prof. L.D.S. Yadav, Dr. J. Singh & Dr. S. Singh. 9. Advanced Organic Chemistry by Prof. J. Singh & Prof. L.D.S. Yadav.

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<table>
<tr><th colspan="4">M.Sc. Semester –IV (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – III</th></tr>
<tr><td>COURSE CODE:
CHE4TH06</td><td>BIOMOLECULES & BIOACTIVE COMPOUNDS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide fundamental understanding of the structure, function, and kinetics of biomolecules such as enzymes, nucleic acids, carbohydrates, and lipids, and their role in biological systems.
2. To develop knowledge of the structure, synthesis, and biological significance of vitamins, antibiotics, pheromones, and other biologically important organic molecules.
3. To enable students to understand biochemical mechanisms, synthetic methods, and analytical techniques involved in the study and application of bioactive compounds.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Gain knowledge of the historical development and unique properties of enzymes.
2. Develop a comprehensive understanding of the structural features of DNA and RNA, the forces responsible for their stability, and the sequencing and solid-phase synthesis methods used for their preparation
3. Acquire knowledge of the different classes of naturally occurring sugars, lipids, and their related derivatives.
4. Gain an understanding of the structures, functions, and applications of specific vitamins, antibiotics, pyrethroids, rotenones, and pheromones, and apply this knowledge in scientific and industrial fields.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT-I

Enzymes

Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Fisher’s lock and key and Koshland’s induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity</td></tr>
</table>

	labeling. Enzyme kinetic, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition, Enzyme immobilization. **UNIT- II** **Nucleic Acids:** Secondary and Tertiary structure of DNA/RNA and stabilizing forces, polymorphic nature of DNA, Sequencing, solid phase synthesis; trimester, phosphoramidite and phosphonate methods, Purification: HPLC and gel electrophoresis. Peptide nucleic acid (PNA). **UNIT- III** **Carbohydrates and Lipids**: Basic structure and type of sugars. Protection and deprotection. Deoxy-sugars, amino sugars, glycal sugars and their synthetic aspects. Introduction to industrially important polysaccharides. Classification and biological importance of fatty acids and lipids, stereochemical notation in lipids Chemistry Structure and role of carbolipids, phospholipids and sphingolipids. **UNIT- IV** **Vitamins and Antibiotics**: Structure elucidation and synthesis of Vitamins B1 and E. Biological role of Vitamin B6 and Vitamin H. Synthesis of Penicillin G, Chloramphenicol and Cephalosporin. Biological role of tetracycline and streptomycin. **UNIT- V** **Pyrethroids and Rotenones, Pheromones**: Synthesis and reactions of Pyrethroids and Rotenones. (For structure elucidation, emphasis is to be placed on the use of parameters wherever possible). Classification of pheromones their synthesis.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 2. Lehninger Principles of Biochemistry, by Nelson, David L., and Michael M. Cox. 7th ed., W.H. Freeman, 2017. 3. Saenger, W. *Principles of Nucleic Acid Structure* Springer-Verlag (1984). 4. Bioorganic Chemistry - A Chemical Approach to Enzyme Action, by H. Dugas, 3rd Ed. Springer, 1999. 5. Stryer, L. *Biochemistry* 4th Ed., W. H. Freeman & Co. (1995).

	6. Sinden, R. P. *DNA Structure and Function* Academic Press (1994). 7. R. F. Doerge, J. B. Lippincott, Wilson & Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, 8th Ed, Philadelphia, USA, 2010 8. Lednicer and Mitscher, Organic Chemistry of Drug Synthesis, Vols I and II, John Wiley, 1980. 9. G. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, Oxford, 1998. 10. D. J. Abraham, Burgers Medicinal Chemistry and Drug Discovery, Vol. I, 6^{th} Ed., John Wiley and Sons, New Jersey, 2003.

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<table>
<tr><td colspan="4">M.Sc. Semester –IV (ORGANIC CHEMISTRY SPECIALIZATION)</td></tr>
<tr><td colspan="4">PAPER – IV (ELECTIVE)</td></tr>
<tr><td>COURSE CODE:
CHE4TH14</td><td>REAGENTS AND REACTIONS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of important reagents used in organic synthesis and their applications in functional group transformations with emphasis on selectivity and stereochemistry.
2. To develop understanding of selective organic reactions, modern synthetic methods, and their mechanistic aspects for efficient construction of organic molecules.
3. To impart knowledge of green chemistry principles and environmentally benign synthetic protocols, including modern name reactions and sustainable approaches in organic synthesis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Develop an understanding of the use of modern synthetic reactions and reagents in organic synthesis.
2. Acquire the knowledge and skills required to use a broad range of reagents in organic synthesis, understand stereochemical aspects of chemical transformations, and carry out selective organic reactions.
3. Develop an understanding of green chemistry principles to promote sustainable synthetic practices and environmentally friendly organic reactions.
4. Become familiar with atom-economical named organic reactions and their applications in chemical synthesis.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT- I

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible) Complex metal hydrides – $NaBH_4$, Sodium cyanoborohydride, $LiAlH_4$ (LAH), Alkoxy substituted LAH, DIBAL, diborane, Selectride, diisoamylborne, thexylborane, 9-BBN, isopinocamphenyl and diisopino-campherylborame, catechoborane Gilman’s reagent, Lithium disopropyl amide (LDA).</td></tr>
</table>

	UNIT- II Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): Dicyclohexylcarbcarbodimide (DCC), DEAD, 1, 3-Dithiane (Reactivity Umpolung), Trimethylsily iodide, Tri n-butyltin hydride, PCC. **UNIT- III** Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): DDQ & SeO_2, Hydrazine, phenylhydrazine & p-Toluenesulfonyl hydrazide, nucleophilicheterocyclic carbenes (NHC), Nitrogen, Sulphur and Phosphorus Ylides-preparation and their synthetic applications. **UNIT-IV** Selective Organic Reaction and their Synthetic Application: Stork Enamine reaction, Ene and related reactions, Reaction at inactivated C-H bonds- Barton Reaction & Hofmann-Loffler- Freytag reaction. Olefine Ring Closing Metathesis. **UNIT- V** Green Chemistry: Introduction of green chemistry basic principles of green chemistry, Green protocol for benzoin condensation, bromination and acylation, organic synthesis using visible light and ionic liquid. Selective Organic name reaction and their Synthetic Application in reference to Green Chemistry: Baylis-Hillman Reaction, Stetter Reaction, Passerinin and Ugi Reactions.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002. 2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 3. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 4. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 5. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004). 6. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge

	University Press (1996). 7. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 8. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 9. P. T. Anastas and T. C. Williamson, Green Chemistry: Frontiers in benign chemical synthesis and processes, Oxford University Press, Oxford, Ed. 1998. 10. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.

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<table>
<tr><th colspan="4">M.Sc. Semester - III (PHYSICAL CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td>COURSE CODE:
CHE3TH07</td><td>STATES OF MATTER</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Develop a fundamental understanding of the kinetic theory of gases, including velocity and energy distribution, molecular collisions, and transport properties.

2. Provide quantitative knowledge of gas transport phenomena such as viscosity, thermal conductivity, and diffusion, and their dependence on temperature, pressure, and molecular parameters.

3. Explain the physical properties of liquids, including surface tension, viscosity, intermolecular forces, and sedimentation equilibrium, along with their theoretical and experimental basis.

4. Introduce structural and thermodynamic models of liquids using statistical mechanics, equation of state, radial distribution function, and intermolecular potential models.

5. Build conceptual and theoretical understanding of solid-state physics, including free electron theory, band theory, semiconductor properties, and superconductivity.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Calculate mean, RMS, and most probable velocities and explain Maxwell’s distribution of molecular velocities.

2. Derive and apply equations for viscosity, diffusion, and thermal conductivity of gases.

3. Evaluate viscosity, surface tension, and intermolecular forces in liquids and interpret their experimental determination.

4. Analyze liquid structure using theoretical models such as radial distribution function and Lennard–Jones potential.</td></tr>
</table>

	5. Explain band theory and classify materials as metals, semiconductors, or insulators based on electronic properties. 6. Describe intrinsic and extrinsic semiconductors and explain the basic principles of superconductivity.
Syllabus	**UNIT – I** **Gaseous State-I** Distribution law (Barometric formula), Maxwell's law of distribution of velocity and energy, Maxwell's law and Gaussian density function, R, M, S, Mean and Most probable velocities, Collision frequency, Collision between like and unlike molecules. **UNIT – II** **Gaseous State –II** Kinetic theory of thermal conductivity and diffusion coefficient of gases (quantitative treatment), viscosity of gases and its relation to mean free path, variation of viscosity with temperature and pressure. Law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. **UNIT-III** **Liquid State-I** Surface tension, Viscosity of liquid and its determination, effect of temperature and pressure on viscosity and surface tension. Sedimentation equilibrium, Internal pressure and its determination, nature of intermolecular forces, oscillating dipoles, dipole-induced dipoles, London theory of dispersion forces, Various contributions of intermolecular forces, hydrogen bonding. **UNIT-IV** **Liquid State-II** Liquids as dense gas and solids, Qualitative structural analysis of liquids by spectroscopic and computational techniques, Radial distribution function method. Equation of state and partition function, Eyring's vacancy theory and free volume theory of liquid viscosity, effect of temp and pressure on viscosity, thermodynamic correlation and determination of free volume. L-J potential, Lennard-Jones and Devonshire cell model. **UNIT-V** **Solid State-II** Free electron theory, Fermi-gas theory and band theory of solids, Metals, semi-conductors and insulators, Intrinsic extrinsic p-type and n-type semi-conductors, Superconductivity, Effect of temperature on superconductivity.
Recommended Books	1. P.A. Egeistaff. An Introduction to Liquid State, Academic Press. 2. A.F.M. Barton, Longman. The Dynamic Liquid State, London Longman Group Ltd. 3. J.A. Pryde. The Liquid State, Hutchinson University Library. 4. H. Eyring and M.S. John. Significant Liquid Structures, John Wiley & Sons Inc.

	5. Walter J. Moore, Prentice-Hall. Physical Chemistry, Prentice-Hall. 6. K. Laidler and J.H. Meiser. Physical Chemistry, Publisher Houghton Mifflin. 7. G.K. Vemulapalli. Physical Chemistry, Prentice Hall of India, New Delhi. 8. David Ball, Physical Chemistry, Cengage India Private Limited. 9. West, A. R. Solid State Chemistry and its Applications 2nd Ed., John Wiley &Sons Ltd. 10. C.W. Bunn. Chemical Crystallography. Oxford at the Clarendon Press.

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<table>
<tr><th colspan="3">M.Sc. Semester - III (PHYSICAL CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="3">PAPER – II</th></tr>
<tr><td>COURSE CODE:
CHE3TH08</td><td>ADVANCED SPECTROSCOPY & MAGNETOCHEMISTRY</td><td>COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)
TOTAL MARKS: 100 | END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="2">The course aims to:
1. Develop fundamental understanding of electronic structure, angular momentum, and magnetic properties of atoms and molecules.
2. Provide theoretical and practical knowledge of molecular spectroscopy techniques such as Raman, NMR, ESR, Mossbauer, and Photoelectron spectroscopy.
3. Explain the interaction of electromagnetic radiation with matter and its application in structural determination.
4. Introduce the principles, instrumentation, and interpretation of advanced spectroscopic techniques for chemical analysis.
5. Develop understanding of magnetochemistry and its applications in determining electronic configuration, bonding, and molecular structure.</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">By the end of this course, the student will be able to:
1. Explain orbital and spin angular momentum, L–S and J–J coupling, and interpret electronic spectra of molecules using spectroscopic principles.
2. Explain Raman effect, interpret rotational and vibrational Raman spectra, and apply Raman spectroscopy for molecular structure determination.
3. Explain the principles of NMR and ESR spectroscopy and interpret chemical shift, coupling constants, hyperfine splitting, and relaxation processes.
4. Explain the principles of Mossbauer spectroscopy and Photoelectron spectroscopy and interpret spectral data for chemical and structural analysis.
5. CO5: Analyze magnetic properties of substances and apply magnetochemical principles to determine magnetic moment, electronic configuration, and molecular structure.
6. Correlate spectroscopic and magnetic data to explain molecular structure, bonding, and electronic properties of chemical systems.</td></tr>
<tr><td>Syllabus</td><td colspan="2">UNIT – I
Advanced Spectroscopy-I
Orbital and spin moments, Electrons and multielectron systems, Magnetic property of complex compound in relation to their structure, Bohr magneton, L-S and J-J couplings. Electronic spectra of molecules, Born-Oppenheimer</td></tr>
</table>

	approximation, Franck-Condon principle, Rotational fine structure of Electronic-Vibration transitions, Predissociation spectra. **UNIT-II** **Advanced Spectroscopy-II** Raman Spectroscopy: Raman Effect, theory of Raman Effect (quantum mechanical and classical), rotational Raman spectra, vibrational Raman spectra, rotational-vibrational Raman spectroscopy, rule of mutual exclusion and structure determination, instrumentation and Application of Raman spectroscopy. **UNIT-III** **Advanced Spectroscopy-III** **NMR Spectroscopy:** Theory of NMR, relaxation process and chemical shift, The coupling constant, nuclear spin interaction, Application of NMR spectroscopy. **ESR spectroscopy:** Principle of ESR, Magnetic moment of electron and splitting factor, Hyper-fine splitting and double resonance in ESR, Application of ESR spectroscopy. **UNIT-IV** **Advanced Spectroscopy-IV** **Mossbauer spectroscopy:** Principle of Mossbauer spectroscopy, Origin of line width, Isomer shift, Quadrupole effects, Application of Mossbauer. **Photo Electron Spectroscopy (PES):** Principles of photoelectron spectroscopy, Koopman's theorem, types of PES, photo ionization constant, chemical shift in Electron Spectroscopy for Chemical Analysis (ESCA), instrumentation, techniques of PES, application of ESCA. **UNIT-V** **Magnetochemistry** Origin of magnetic moment, paramagnetic-, diamagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetism. Pascal's law and its applications. Magnetic susceptibility and its determination, susceptibility equivalents, Diamagnetism of elements, Compounds and its ions, Langevin's theory of paramagnetism, Curie's law, Weiss molecular field theory of paramagnetism, Curie- Weiss law, Determination of Curie point.
Recommended Books	1. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press. 2. Banwell, C.N., & Mc Cash, Elaine M., Fundamental of molecular spectroscopy 3rd Ed., UK. Mc Graw-Hill Companies. 3. Barrow, G.M., Introduction to molecular spectroscopy. USA, Mc Graw-Hill Companies. 4. Ira n. Lavine Molecular Spectroscopy Publisher: New York, Wiley. 5. Hollas, J.M., Modern spectroscopy 4th Ed., USA, John Wiley & Sons Ltd.

	6. Brown, J. M., Rotational spectroscopy of diatomic molecules, UK, Cambridge University Press. 7. H. E. White, Atomic Spectroscopy, USA, Mc Graw-Hill Companies. 8. Selwood, P.W., Magneto chemistry, Swin burne Press. 9. Donald A Mc Quarrie and John D Simon, Physical Chemistry: A molecular approach, University Science Books Sausalito, California

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<tr><td colspan="4">M.Sc. Semester - III (PHYSICAL CHEMISTRY SPECIALIZATION)</td></tr>
<tr><td colspan="4">PAPER – III</td></tr>
<tr><td>COURSE CODE:
CHE3TH09</td><td>ADVANCED CHEMICAL KINETICS
&
CATALYSIS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Develop advanced understanding of reaction kinetics and molecular reaction mechanisms.
2. Explain theoretical models of unimolecular reactions and the thermodynamic formulation of rate constants.
3. Provide knowledge of fast reaction techniques and their applications in studying reaction mechanisms.
4. Introduce the principles, theories, and mechanisms of homogeneous and heterogeneous catalysis.
5. Develop understanding of enzyme catalysis, nanocatalysis, and industrial catalytic processes.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Explain unimolecular reaction theories such as Lindemann, Hinshelwood, RRK, and RRKM, and interpret thermodynamic aspects of reaction rate constants.
2. Apply steady-state and equilibrium approximations, linear free energy relationships, and substituent effects to analyze reaction rates and mechanisms.
3. Explain principles and applications of fast reaction techniques such as stop-flow, relaxation methods, flash photolysis, and magnetic resonance methods.
4. Analyze oscillatory reactions and explain mechanisms such as the Belousov–Zhabotinsky reaction.
5. Explain theories and mechanisms of homogeneous and heterogeneous catalysis, including adsorption and surface reaction models.
6. Analyze catalytic processes including enzyme catalysis, nanocatalysis, industrial catalysis, and Langmuir–Hinshelwood and Langmuir–Rideal mechanisms.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT – I
Advanced Chemical Kinetics -I
Unimolecular reactions: treatment of Lindemann, Hinshelwood, Rice-Ramsperger- Kassel (RRK), and Rice- Ramsperger-Kassel-Marcus (RRKM) theories; thermodynamic formulation of rate constant; transmission co-efficient.</td></tr>
</table>

	UNIT-II **Advanced Chemical Kinetics-II** Study of equilibrium constant and steady state treatment for Arrhenius and Vant Hoff's complexes, Influence of substituents on reaction rates (inductive and electrometric effects), Linear free energy relationship, Taft equation. **UNIT-III** **Advanced Chemical Kinetics-III** Fast reactions: Techniques to study fast reactions, flow method (i.e. stop-flow method), relaxation method (i.e. T-jump method), flash photolysis and magnetic resonance method; kinetics of fast reactions. Oscillatory reactions: Kinetics of oscillatory reactions with special reference to Belousov–Zhabotinsky mechanism (B-Z mechanism). **UNIT-IV** **Catalysis-I** Characteristics of catalysis; Theories of catalysis: Intermediate compound formation theory, adsorption theory for heterogeneous catalysis; Homogeneous catalysis: Kinetics of the homogeneous and acid-base catalysis, catalytic coefficients, effect of pH on reaction velocity. **UNIT-V** **Catalysis-II** Heterogeneous catalysis: Mechanism of heterogeneous catalysis, role of surfaces in heterogeneous catalysis; Nano catalysis; Enzyme catalysis; Industrial Catalysts: Catalyst poisons, inhibitor, carrier, promoter. Langmuir-Hinshelwood mechanism, Langmuir-Rideal mechanism, Inhibition of surface reactions, Absolute reaction rate theory of surface reactions.
Recommended Books	1. Reaction Kinetics, M. J. Pilling and A.P.W, Seakins, Oxford Science Publication, New York 2. Chemical Kinetics, 3rd Ed., K.J. Laidler, Harper & Row Publishers, New York. 3. Theories of Molecular Reaction Dynamics: The Microscopic Foundation of Chemical Kinetics, N. E. Henriksen, F. Y. Hansen, Oxford University Press Inc., New York 4. Theory of Unimolecular Reactions, W. Forst, Academic Press Inc., New York 5. Physical Chemistry, K.J. Laidler, J.H. Meiser, CBS Publishers & Distributors. 6. Atkin’s, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press. 7. Rajaraman, J., Kuriacose, J. C., Kinetics and Mechanism of Chemical Transformations, India, Macmillan Publishers India Limited

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<table>
<tr><th colspan="4">M.Sc. Semester –III</th></tr>
<tr><th colspan="4">PAPER – IV(Elective)</th></tr>
<tr><td>COURSE CODE:
CHE3TH14</td><td>SPECTROSCOPY OF ORGANIC COMPOUNDS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of NMR spectroscopy (^{1}H and ^{13}C), including spectral interpretation, coupling phenomena, advanced techniques, and their application in structural analysis of organic compounds.
2. To develop understanding of mass spectrometry, including ionization methods, fragmentation patterns, and spectral interpretation for molecular structure determination.
3. To enable students to apply combined spectroscopic techniques (UV, IR, NMR, and Mass spectrometry) for accurate identification and structural elucidation of organic molecules.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Exhibit a thorough understanding of Nuclear Magnetic Resonance (NMR) spectroscopy and apply it to interpret complex spectra and determine molecular structures.
2. Utilize advanced NMR concepts, including virtual coupling, stereochemical effects, and the Karplus relationship, for accurate interpretation of spectral data.
3. Analyse Carbon-13 NMR spectra by evaluating chemical shifts, coupling patterns, and specialized techniques such as DEPT, INEPT, and APT, and apply two-dimensional NMR methods for detailed structural elucidation.
4. Explain the fundamental principles and applications of Mass Spectrometry and use mass spectral data to identify and confirm the structures of organic molecules.</td></tr>
</table>

	5. Integrate information obtained from UV, IR, ^{1}H NMR, ^{13}C NMR, and Mass Spectrometry to systematically determine the structures of organic compounds.
Syllabus	**UNIT-I** **Nuclear Magnetic Resonance Spectroscopy I**: PMR Spectroscopy chemical exchange, effect of deuteration, complex spin-spin interaction between two, three four and five nuclei (first order spectra). **UNIT-II** **Nuclear Magnetic Resonance Spectroscopy II**: Virtual coupling, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplication of complex spectra-nuclear magnetic double resonance, contract shift reagents, solvent effects. Fourier transform technique, Nuclear Overhauser Effect (NOE)-NOESY. Resonance of other nuclei: F, P, N. Structural problems based on PMR. **UNIT-III** **Nuclear Magnetic Resonance Spectroscopy III**: Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Off- resonance decoupling, DEPT, INEPT, APT techniques. Two- dimension, NMR spectroscopy: COSY, HMBC and INADEQUATE techniques. Structural problem based on ^{13}C NMR. **UNIT-IV** **Mass Spectrometry**: Introduction, ion production-EI, CI, FAB, ESI, APCI, MALDI, factors affecting fragmentation, ion analysis, ion abundance, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Isotopic peaks. Mc-Lafferty rearrangement, Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect of their structure determination. **UNIT-V** Structural problems by joint application of UV, IR, NMR (^{1}H & ^{13}C) and mass spectroscopy.
Recommended Books	1. Organic Spectroscopy, Prof L. D. S. Yadva, Springer (2005). 2. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Brooks

	Cole, 5th Ed., 2015. 3. R.M. Silverstein, F. X. Webster, Spectrometric Identification of Organic compounds, John Wiley & Sons Inc., 7th Ed., 2011. 4. D.H Williams & I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata Mcgraw Hill Education, 6th Ed., 2011. 5. W. Kemp, Organic Spectroscopy, Palgrave Macmillan, 3rd Ed., 1991. 6. L. D. Field, H. L. Li., A. M. Magill, Organic Structures from 2D NMR Spectra, Wiley, 2015. 7. L. D. Field, S. Sternhell and J R Kalman, Organic Structures from spectra; John Wiley & Sons Ltd., 2007.

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<table>
<tr><th colspan="4">M.Sc. Semester - IV (PHYSICAL CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – I</th></tr>
<tr><td>COURSE CODE:
CHE4TH07</td><td>QUANTUM & STATISTICAL MECHANICS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td colspan="2"></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Develop advanced understanding of quantum mechanical operators and their applications to atomic systems.
2. Provide theoretical knowledge of quantum mechanical models such as Valence Bond and Molecular Orbital theories.
3. Introduce Huckel molecular orbital theory and advanced quantum mechanical methods for molecular structure determination.
4. Develop understanding of statistical mechanics and its application to thermodynamic properties of atoms, molecules, and solids.
5. Explain quantum statistics and their applications to physical systems such as electron gas and molecular systems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Apply quantum mechanical operators and solve the Schrödinger equation for hydrogen atom and interpret angular momentum and uncertainty principles.
2. Explain Valence Bond theory and Molecular Orbital theory and apply them to describe bonding in homonuclear and heteronuclear diatomic molecules.
3. Apply Huckel Molecular Orbital theory to determine molecular properties such as energy levels, bond order, charge density, and delocalization energy.
4. Apply statistical mechanics to calculate heat capacities and equilibrium constants using partition functions.
5. Explain and compare Maxwell–Boltzmann, Bose–Einstein, and Fermi–Dirac statistics and their applications to physical systems such as electron gas and liquid helium.
6. Apply statistical thermodynamics to explain molecular systems such as ortho and para hydrogen and thermodynamic behavior of solids and gases.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT – I
Quantum Mechanics-II: Concept of operators in quantum mechanics—operators for velocity, kinetic energy, momentum and angular momentum, Ladder Operators, Hermitian operator. Derivation of Heisenberg's uncertainty principle, Solution for Hydrogen atom (separation of radial and angular parts).</td></tr>
</table>

	UNIT-II **Quantum Mechanics-III** Born-Oppenheimer approximation, Valence bond theory and its application to homonuclear (Hydrogen) and heteronuclear (HCl) diatomics, LCAO-MO treatment of hydrogen molecule ion, Comparative study of MO and VB theory. **UNIT-III** **Quantum Mechanics-IV:** Huckel molecular orbital theory and its application to hybridization systems (ethylene, butadiene, allyl and benzene), Calculation of delocalization energy, Physical significance of charge density and bond order, Calculation of bond length, Pauling and Wheland's modification in HMO theory and it application to heteromolecules (pyrimidine), Perturbation methods in LCAO-MO theory, Extended Huckel molecular orbital theory and SCF-MO method. **UNIT- IV** **Statistical Mechanics-II** Heat capacity of hydrogen at low temperatures, Heat capacities of monoatomic crystals, The Einstein model, Debye's theory of solid, Heat capacities of crystals at very low temperatures. Expression of equilibrium constant in terms of partition functions. Equilibrium constants of simple system-(i) Ionization of metal atoms, (ii) Dissociation of diatomic molecules and (iii) Isotopic exchange equilibria. **UNIT-V** **Statistical Mechanics-III** Bose-Einstein statistics, Fermi Dirac Statistics, Comparison of M-B, B-E and F-D statistics, Fermi- Dirac gas (Electron gas in metals)- Bose —Einstein gas (liquid Helium). Statistical thermodynamics of ortho and para hydrogen.
Recommended Books	1. Pauling and Wilson, Introduction to Quantum Mechanics, Dover Publications Inc. 2. Ira N. Levine Advanced Quantum Chemistry, Pearson publisher. 3. Cohen-Tannoudji, Claude; Diu, Bernard; Laloë, Franck. Quantum Mechanics, Publisher Wiley-VCH. 4. JJ Sakurai, J. Napolitano. Modern Quantum Mechanics 2nd Ed., Pearson publisher. 5. McQuarrie, Donald A. Statistical Mechanics, University Science Books. 6. Pathria, R. K.; Beale, Paul. Statistical Mechanics, Elsevier Publication. 7. Stowe, Keith. Introduction to Statistical Mechanics and Thermodynamics, Cambridge University Press. 8. Chandler, David. Introduction to Modern Statistical Mechanics, Oxford University Press, New York

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<table>
<tr><th colspan="4">M.Sc. Semester - IV (PHYSICAL CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – II</th></tr>
<tr><td>COURSE CODE:
CHE4TH08</td><td>POLYMER & COLLOIDAL CHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td></td><td></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Develop understanding of polymerization mechanisms and kinetics, including chain and ionic polymerization processes.
2. Provide knowledge of coordination polymerization, polymer degradation, conducting polymers, and polyelectrolytes.
3. Explain the properties, stability, and behavior of colloidal systems and their applications.
4. Introduce the principles of surfactants, micellization, and thermodynamics of colloidal systems.
5. Develop understanding of surface chemistry, adsorption phenomena, and their applications in material characterization and industrial processes.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Explain mechanisms and kinetics of chain polymerization, ionic polymerization, and copolymerization, including monomer reactivity ratios.
2. Explain coordination polymerization, polymer degradation processes, conducting polymers, and polyelectrolyte behavior.
3. Analyze types, properties, and stability of colloidal systems, including stabilization mechanisms and characterization methods.
4. Explain micelle formation, critical micelle concentration (CMC), and thermodynamics of micellization in surfactant systems.
5. Apply adsorption theories such as Freundlich, Langmuir, and BET isotherms to analyze surface phenomena and determine surface area.
6. Explain ion exchange, adsorption processes, and surface films and their applications in chemical and industrial systems.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT – I
Polymer Chemistry -II
Kinetic of initiation retardation, chain polymerization and ionic polymerization (anionic and cationic), Copolymerisation (with special reference to monomer reactivities ratios).

UNIT-II
Polymer Chemistry -III</td></tr>
</table>

	Coordination polymerization, Degradation of polymers (oxidative, chemical and photolytic), An introduction to conducting polymers, Polyelectrolytism, **UNIT-III** **Colloids Chemistry-I** Types of colloids, forces between colloidal particles, characterization of colloids, charge stabilization, steric stabilization, effect of polymer on colloid stability, kinetic properties, sols, gels, clays, foams, emulsions, food colloids, concentrated colloidal dispersions. **UNIT-IV** **Colloids Chemistry-II** Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization, phase separation and mass action models, reverse micelles, solubilization. **UNIT-V** **Surface Chemistry** Concept of Adsorption, Physisorption, Chemisorption, Factors effecting adsorption, Freundlich adsorption isotherm, Langmuir adsorption isotherm, Gibbs adsorption isotherm, BET theory of multi-layer adsorption, BET equation, and its application to surface area measurements, Adsorption of solids from solution, Gibbs adsorption equation, Surface films on liquids. Ion exchange adsorption and its applications.
Recommended Books	1. Fundamentals of photo chemistry, K.K. Rothagi-Mukheriji, 3rd Ed., New Age Publishers. 2. Essentials of Molecular Photochemistry, A Gilbert and J. Baggott, Blackwell Scientific. 3. Molecular Photochemistry, N. J. Turro, University Science Books. 4. Introductory Photochemistry, A. Cox and t. Camp, McGraw Hill. 5. Hiemenz, Paul C., Raj Rajagopalan, Principles of colloid and Surface Chemistry 3rd Ed., Marcel Dekker, Inc. 6. Shaw, D. J. Introduction to Colloid and Surface Chemistry 2nd Ed. Butterworths. 7. Brian Wardle, Principles and Applications of Photochemistry, Manchester Metropolitan, University, Manchester, UK 8. Marco Montalti, Alberto Credi, Luca Prodi, M. Teresa Gandolfi. Hand Book of Photo Chemistry 3rd Ed., CRC Press. 9.Adamson, A. W. & Gast, A. P. Physical Chemistry of Surfaces 6th Ed., Wiley. 10. Gabor, A., Somorjai, Yimin L. Introduction to Surface Chemistry & Catalysis, New York, John Wiley & Sons.

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<table>
<tr><th colspan="4">M.Sc. Semester - IV (PHYSICAL CHEMISTRY SPECIALIZATION)</th></tr>
<tr><th colspan="4">PAPER – III</th></tr>
<tr><td>COURSE CODE:
CHE4TH09</td><td>ADVANCED THERMODYNAMICS & ELECTROCHEMISTRY</td><td colspan="2">COURSE CREDIT: 3
HOURS: 45 (3 x 15 = 45 Hours)</td></tr>
<tr><td colspan="2"></td><td>TOTAL MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td>Course Objectives</td><td colspan="3">The course aims to:
1. Develop advanced understanding of thermodynamic properties of ideal and non-ideal solutions and excess thermodynamic functions.
2. Introduce the principles and laws of non-equilibrium thermodynamics and entropy production in physical and chemical processes.
3. Explain Onsager reciprocal relations and thermodynamic treatment of transport processes such as diffusion and electrical conduction.
4. Provide theoretical knowledge of electrolyte conductance, interionic interactions, and Debye–Hückel–Onsager theory.
5. Develop understanding of electrode kinetics, overpotential, electrochemical reactions, and electrical double layer models.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">By the end of this course, the student will be able to:
1. Explain thermodynamic properties of ideal and non-ideal solutions, including activity, activity coefficients, and excess thermodynamic functions.
2. Apply thermodynamic principles to determine partial molar properties and interpret thermodynamic behavior of solutions.
3. Explain entropy production, linear laws, and phenomenological relations in non-equilibrium thermodynamic systems.
4. Analyze transport processes using Onsager reciprocity relations and explain diffusion, electrokinetic, and electrical conduction phenomena.
5. Apply Debye–Hückel–Onsager theory and related models to explain electrolyte conductance and interionic interactions.
6. Explain electrode kinetics, Butler–Volmer equation, overpotential, and electrical double layer models in electrochemical systems.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT – I
Advanced Thermodynamics-III
Ideal and non-ideal solutions, Thermodynamic functions of mixing of non-ideal solutions, Gibbs-Duhem-Margules equation and its applications, Activity and activity coefficients, Activity coefficients from excess thermodynamic function, Partial molar properties, Determination of Partial Molar Properties, Excess thermodynamic function and determination of excess function.</td></tr>
</table>

	UNIT-II **Non-Equilibrium Thermodynamics-I** Thermodynamic functions for non-equilibrium states, Postulates and methodology, Linear laws, Gibbs equation, Thermodynamic criteria for non-equilibrium states, entropy production, entropy production in heat flow and matter flow, entropy production in chemical reaction. Entropy production in open system. Entropy production due to flow of current in electrical conductor, The phenomenological law. **UNIT-III** **Non-Equilibrium Thermodynamics-II** Microscopic reversibility and Onsager's reciprocity relations transformations properties of the generalized fluxes and forces, non-equilibrium stationary states (Prigogine's principle of minimum entropy production), electro kinetic phenomena, diffusion. electrical conductor. **UNIT-IV** **Advanced Electrochemistry-I** Asymmetry and electrophoretic effects, Stoke's law and Walden product, Debye-Huckel- Onsager equation, Conductance ratio and the Onsager slope, Verification of Debye- Huckel Onsager equation, Modifications of Debye-Huckel-Onsager equation, Fuoss-Onsager and other equations. **UNIT-V** **Advanced Electrochemistry-II** Decomposition potential, Overpotential, Hydrogen overvoltage, Exchange current density, derivation of Butler-Volmer equation, The current-potential relation, The Tafel equation, H_2-Evolution mechanism. Lippmann equations (surface excess), determination of surface excess, structure of electrified interfaces double layer: parallel-plate condenser model (Helmholtz-Perrin theory), Guoy Chapman model, Stern model.
Recommended Books	1. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press. 2. Castellan, G.W., Physical Chemistry 3rd Ed., USA, Addison-Wesley Publishing Company. 3. Groot, SR. de., Mazur, P., Non- Equilibrium Thermodynamics, Amsterdam, North-Holland Publishing Company. 4. E. N. Yeremin. Fundamentals of Chemical Thermodynamics, MIR Publishers, Moscow. 5. IRAN. Levine. Physical Chemistry, Mc Graw Hill. 6. Bard, A. J., Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications, 2nd Ed., New York, John Wiley & Sons. 7. Bockris, J. O' M., Reddy, A. K. N. Modern Electrochemistry 1: Ionics 2nd Ed., USA, Springer. 8. Bockris, J. O' M., Reddy, A. K. N. & Gamboa-Aldeco, M. E. Modern Electrochemistry 2-A: Fundamentals of Electrodics 2nd Ed., USA Springer.

	9. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2-B: Electrodics in Chemistry, Engineering, Biology and Environmental Science 2nd Ed., USA, Springer. 10. Brett, C. M. A. & Brett, A. M. O. Electrochemistry-Principle, methods and application, UK, Oxford University Press. 11. Koryta, J., Dvorak, J. & Kavan, L. Principles of Electrochemistry, New York, John Wiley & Sons. 12. Glasstone, Samuel, An Introduction to Electrochemistry, East-West Press Pvt. Ltd.

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<table>
<tr><th colspan="4">M.Sc. Semester –IV (ORGANIC CHEMISTRY SPECIALIZATION)</th></tr>
<tr><td colspan="4">PAPER – IV (ELECTIVE)</td></tr>
<tr><td>COURSE CODE:
CHE4TH14</td><td>REAGENTS AND REACTIONS</td><td colspan="2">COURSE CREDIT: 3
HOURS: 3 x 15 Hours = 45 Hours</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>TOTAL
MARKS: 100</td><td>END SEMESTER: 60
C.I.A.: 40</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="3">1. To provide comprehensive knowledge of important reagents used in organic synthesis and their applications in functional group transformations with emphasis on selectivity and stereochemistry.
2. To develop understanding of selective organic reactions, modern synthetic methods, and their mechanistic aspects for efficient construction of organic molecules.
3. To impart knowledge of green chemistry principles and environmentally benign synthetic protocols, including modern name reactions and sustainable approaches in organic synthesis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">After successful completion of this course, students will be able to:
1. Develop an understanding of the use of modern synthetic reactions and reagents in organic synthesis.
2. Acquire the knowledge and skills required to use a broad range of reagents in organic synthesis, understand stereochemical aspects of chemical transformations, and carry out selective organic reactions.
3. Develop an understanding of green chemistry principles to promote sustainable synthetic practices and environmentally friendly organic reactions.
4. Become familiar with atom-economical named organic reactions and their applications in chemical synthesis.</td></tr>
<tr><td>Syllabus</td><td colspan="3">UNIT- I
Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible) Complex metal hydrides – $NaBH_4$, Sodium cyanoborohydride, $LiAlH_4$ (LAH), Alkoxy substituted LAH, DIBAL, diborane, Selectride, diisoamylborne, thexylborane,</td></tr>
</table>

	9-BBN, isopinocamphenyl and diisopino-campherylborame, catechoborane Gilman's reagent, Lithium disopropyl amide (LDA). **UNIT- II** Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): Dicyclohexylcarbcarbodimide (DCC), DEAD, 1, 3-Dithiane (Reactivity Umpolung), Trimethylsily iodide, Tri n-butyltin hydride, PCC. **UNIT- III** Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): DDQ & SeO_2, Hydrazine, phenylhydrazine & p-Toluenesulfonyl hydrazide, nucleophilicheterocyclic carbenes (NHC), Nitrogen, Sulphur and Phosphorus Ylides-preparation and their synthetic applications. **UNIT-IV** Selective Organic Reaction and their Synthetic Application: Stork Enamine reaction, Ene and related reactions, Reaction at inactivated C-H bonds-Barton Reaction & Hofmann-Loffler- Freytag reaction. Olefine Ring Closing Metathesis. **UNIT- V** Green Chemistry: Introduction of green chemistry basic principles of green chemistry, Green protocol for benzoin condensation, bromination and acylation, organic synthesis using visible light and ionic liquid. Selective Organic name reaction and their Synthetic Application in reference to Green Chemistry: Baylis-Hillman Reaction, Stetter Reaction, Passerinin and Ugi Reactions.
Recommended Books	1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002. 2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002. 3. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 4. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 5. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts

	A & B, Plenum: U.S. (2004). 6. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996). 7. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 8. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 9. P. T. Anastas and T. C. Williamson, Green Chemistry: Frontiers in benign chemical synthesis and processes, Oxford University Press, Oxford, Ed. 1998. 10. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.