ANDHRA MAHILA SABHA
ARTS & SCIENCE COLLEGE FOR WOMEN
Autonomous - NAAC Re-Accredited,
O.U.Campus, Hyderabad – 500 007

Scheme of Instruction, Evaluation
And Syllabus of
M.Sc (Organic Chemistry)
With effect from Academic Year
2025-2026

Department of Chemistry

Program Objectives (POs) for MSc Organic Chemistry

PO 1: To equip graduates with comprehensive knowledge of organic chemistry principles and theories.

PO 2: To develop practical skills in advanced synthetic methods and analytical techniques used in organic chemistry.

PO 3: To enable graduates to apply scientific methods and critical thinking to solve chemical problems.

PO 4: To prepare graduates for independent research by fostering abilities to design, conduct, and analyze experiments.

PO 5: To instill awareness of ethical, safety, and environmental issues relevant to chemical research and industrial practices.

PO 6: To promote effective communication, teamwork, and leadership skills for professional success in academia and industry.

Programme Outcomes (POs)

PO 1: Demonstrate comprehensive knowledge of fundamental and advanced organic chemistry concepts.

PO 2: Apply synthetic and analytical techniques to perform organic reactions and characterize compounds.

PO 3: Analyze experimental data and interpret results to solve chemical problems.

PO 4: Design and conduct independent research projects to contribute to scientific knowledge.

PO 5: Evaluate ethical, safety, and environmental aspects related to chemical research and industrial processes.

PO 6: Communicate scientific ideas effectively in written, oral, and digital formats.

PO 7: Demonstrate teamwork, leadership, and professional ethics in multidisciplinary environments.

Program Specific Outcomes (PSOs)

PSO 1: Apply advanced organic synthesis techniques to design and develop novel organic compounds and reaction pathways.

PSO 2: Utilize modern analytical instruments such as NMR, IR, Mass Spectrometry, and Chromatography for structure elucidation and purity analysis.

PSO 3: Conduct systematic research by planning, executing, and interpreting experimental data to solve complex problems in organic chemistry.

PSO 4: Evaluate reaction mechanisms and kinetics to optimize chemical processes for academic or industrial applications.

PSO 5: Demonstrate knowledge of green chemistry principles and implement sustainable practices in organic synthesis.

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Osmania University
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SEMESTER – I

Inorganic Chemistry

Course Objectives:

Molecular Symmetry and Point Groups

- Understand symmetry elements, operations, and point group classification.
- Apply symmetry to predict molecular properties like dipole moment and optical activity.
- Recognize the role of symmetry in bonding and spectroscopy.

Bonding in Coordination Complexes

- Learn the principles of Crystal Field Theory and d-orbital splitting in different geometries.
- Analyze factors influencing crystal field splitting and calculate CFSE.
- Study magnetic properties of complexes and their relation to oxidation state, stereochemistry, and spin crossover.

Coordination Equilibria and Stability

- Understand solvation and complex formation in solution.
- Examine stability constants, stepwise and overall equilibria, and influencing factors.
- Learn methods of stability constant determination.
- Apply Irving–Williams order and HSAB theory to predict stability and reactivity of complexes.

Ligational Aspects of Diatomic molecules

- Explain the molecular orbital structures and donor-acceptor behavior of CO, NO, and N_2 as ligands in coordination complexes.
- Analyze bonding modes, stretching frequencies, and structural features of metal carbonyl, nitrosyl, and dinitrogen complexes using spectroscopic and electronic data.
- Evaluate stereo electronic effects and design metal-diatomic complexes that obey the 18-electron rule and exhibit specific bonding characteristics.

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Course Outcomes

After completing this course, students will be able to:

Molecular Symmetry and Point Groups

- Identify symmetry elements and operations in molecules.
- Classify molecules into appropriate point groups using flow charts.
- Apply symmetry concepts to predict physical properties such as dipole moment and optical activity.

Bonding in Coordination Complexes

- Explain the principles of Crystal Field Theory and predict d-orbital splitting in various geometries.
- Calculate Crystal Field Stabilization Energy (CFSE) and correlate it with the stability and electronic configurations of complexes.
- Analyze the magnetic properties of coordination compounds and interpret oxidation states, stereochemistry, and spin crossover behavior.

Coordination Equilibria and Stability

- Explain solvation and formation of metal complexes in solution.
- Distinguish between stepwise and overall stability constants and evaluate factors affecting stability.
- Apply pH-metric, spectrophotometric, and polarographic methods for determining stability constants (basic principles).
- Utilize Irving–Williams order and HSAB principles to predict stability, reactivity, and selectivity of coordination complexes.

Ligational Aspects of Diatomic molecules

- Describe the molecular orbital structures and bonding modes of diatomic ligands such as CO, NO, and N_2 in metal complexes.
- Interpret and analyze spectroscopic data (bond lengths, stretching frequencies) to determine ligand coordination and electron count in metal carbonyl, nitrosyl, and dinitrogen complexes.
- Design new metal-ligand complexes by applying the 18-electron rule and evaluating stereoelectronic factors influencing ligand behavior.

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Organic Chemistry

Course Objectives:

Stereochemistry

- To understand molecular representations, symmetry, chirality, and configurational nomenclature.
- To study relative and absolute configuration, racemisation, and resolution methods.
- To learn configuration determination in E/Z isomers, aldoximes, and ketoximes.

Reaction Mechanism – I

- To introduce methods for determining reaction mechanisms and intermediates.
- To study electrophilic addition, elimination, and nucleophilic aromatic substitution mechanisms.
- To apply isotopic labeling, IR, and NMR in mechanistic studies.

Conformational Analysis (Acyclic Systems)

- To understand conformational isomerism, nomenclature, and conformations of acyclic compounds.
- To learn experimental methods of conformational analysis (dipole moment, UV, IR, NMR).
- To analyze conformational effects on stability, reactivity, and apply the Curtin–Hammett principle.

Heterocyclic compounds &Natural products

- Describe the synthesis, nomenclature, and reactivity of heterocyclic compounds such as indole, quinoline, and acridine.
- Analyze structural features and biosynthetic principles of terpenoids and alkaloids using the isoprene rule.
- Design synthetic pathways for natural products like α-terpeniol, camphor, and papaverine.

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Course Outcomes :

After completing this course, students will be able to:

Stereochemistry

- Represent organic molecules using wedge, Fischer, Newman, and Sawhorse projections.
- Identify molecular symmetry, chirality, and types of chirality (axial, planar, helical).
- Determine absolute and relative configurations, and apply methods of racemisation and resolution.
- Assign E/Z configurations and determine stereochemistry of oximes.

Reaction Mechanism – I

- Demonstrate knowledge of methods for studying reaction mechanisms and intermediates.
- Explain stereochemistry of electrophilic additions and eliminations (E1, E2, E1CB).
- Differentiate between substitution and elimination pathways.
- Describe nucleophilic aromatic substitution mechanisms with supporting evidence.

Conformational Analysis (Acyclic Systems)

- Recognize conformational isomerism and use Klyne–Prelog terminology.
- Analyze conformations of simple acyclic and unsaturated compounds.
- Apply physical methods (UV, IR, NMR, dipole moment) in conformational analysis.
- Evaluate conformational effects on reactivity, stability, and apply Curtin–Hammett principle.

Heterocyclic compounds &Natural products

- Describe the nomenclature, synthesis, and reactivity of key heterocyclic compounds such as indole, quinoline, and acridine.
- Analyze the structural features and biosynthetic principles of terpenoids and alkaloids using the isoprene rule and synthetic pathways.
- Evaluate synthetic strategies and design reaction schemes for the preparation of natural products like α-terpeniol, camphor, and papaverine.

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Physical Chemistry

Course Objectives :

Thermodynamics

- To understand the third law of thermodynamics and the concept of entropy.
- To study Gibbs equations, chemical potential, and phase equilibria.
- To apply thermodynamics to solutions (ideal, non-ideal) and colligative properties.

Electrochemistry

- To learn the principles of electrochemical cells and the Nernst equation.
- To study electrode types, EMF measurements, and applications in chemistry.
- To understand electrolyte solutions through Debye–Hückel theory and ionic conductance models.

Quantum Chemistry – I

- To understand the fundamentals of wave mechanics and Schrödinger's equation.
- To learn the postulates of quantum mechanics and their physical interpretation.
- To apply quantum mechanical models (particle in a box) to chemical problems and spectroscopy.

Chemical Kinetics- I

- Explain the principles of reaction rate theories including collision theory, transition state theory, and the Eyring equation.
- Analyze mechanisms of unimolecular and complex reactions, and derive rate laws using steady-state approximations.
- Evaluate structure–reactivity relationships using Hammett, Taft, and other correlation equations to predict reaction behavior.

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Course Outcomes :

After completing this course, students will be able to:

Thermodynamics

- Apply the third law to evaluate entropies and equilibrium conditions.
- Use Gibbs equations, Clausius–Clapeyron, and van't Hoff relations for chemical and phase equilibria.
- Distinguish between ideal and non-ideal solutions using Raoult's law, Henry's law, fugacity, and activity coefficients.
- Apply thermodynamic principles to colligative properties of multicomponent systems.

Electrochemistry

- Derive and apply the Nernst equation to electrochemical cells.
- Explain electrode types, EMF measurements, and their applications.
- Analyze electrode polarization, overpotential, and decomposition potential.
- Apply Debye–Hückel theory and the Debye–Hückel–Onsager equation to ionic activity and conductance.

Quantum Chemistry – I

- Apply operator algebra, eigenvalues, and eigenfunctions in quantum systems.
- Interpret the wave function and quantum postulates.
- Solve Schrödinger's equation for particle-in-a-box models and calculate observables.
- Apply quantum models to explain molecular spectra.

Chemical Kinetics- I

- Explain the principles of reaction rate theories including collision theory, transition state theory, and the derivation of the Eyring equation.
- Analyze unimolecular and complex reaction mechanisms, rate laws, and the influence of structural factors using Hammett and Taft equations.
- Evaluate structure–reactivity correlations and predict reaction behavior in nucleophilic substitution and electron transfer processes using advanced kinetic models.

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Advanced Spectroscopic Methods

Course Objectives :

Techniques of Chromatography

- To understand the principles, instrumentation, and applications of GC, HPLC, and UV-Vis spectroscopy.
- To learn separation parameters, efficiency theories, and structure–absorption correlations.
- Apply chromatographic methods to quantify and evaluate pharmaceutical compounds and pesticide residues in various sample matrices.

NMR Spectroscopy – I

- To study the basic principles, instrumentation, and chemical shift concepts in ^{1}H NMR.
- To analyze splitting patterns, coupling constants, and proton equivalence.
- To apply NMR in studying organic molecules, metal complexes, and reaction mechanisms.

Vibrational Spectroscopy

- To understand IR and Raman spectroscopy, vibrational energy levels, and selection rules.
- To study normal modes, group frequencies, and stereochemical effects.
- To explore instrumentation and applications of FTIR and Raman spectroscopy.

Electronic spectroscopy

- Explain the principles of electronic spectroscopy, including selection rules and types of electronic transitions.
- Analyze chromophores, conjugated systems, and structural effects on absorption spectra using Woodward-Fieser rules.
- Apply Beer-Lambert law to quantify mixture components and determine dissociation constants of weak acids.

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Course Outcomes:

After completing this course, students will be able to:

Techniques of Chromatography

- Explain principles and applications of GC and HPLC, including detectors and derivatization.
- Evaluate separation efficiency using resolution, plate, and rate theories.
- Apply chromatographic techniques to quantify and evaluate pharmaceutical compounds and pesticide residues in real-world samples.

NMR Spectroscopy – I

- Interpret ^{1}H NMR spectra using chemical shifts, integration, and spin–spin coupling.
- Distinguish between homotopic, enantiotopic, and diastereotopic protons.
- Apply NMR to study tautomerism, hydrogen bonding, conformations, and structures of organic molecules and complexes.

Vibrational Spectroscopy

- Describe vibrational energy levels, selection rules, and group frequencies in IR.
- Analyze stereochemical and isotopic effects on vibrational spectra.
- Compare IR and Raman spectra and explain their complementary nature.
- Apply FTIR and Raman spectroscopy for structural and functional group analysis.

Electronic spectroscopy

- **Understand** the fundamental principles of electronic transitions, selection rules, and molecular energy levels.
- **Apply** Woodward-Fieser rules to predict absorption maxima in conjugated and aromatic systems.
- **Analyze** spectral data using Beer-Lambert law to determine mixture composition and dissociation constants.

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SEMESTER – II

Inorganic Chemistry

Course Objectives

Reaction Mechanisms of Transition Metal Complexes

- Study ligand substitution reactions and their mechanisms.
- Understand energy profiles, transition states, and Langford–Gray classification.
- Learn substitution mechanisms in octahedral and square-planar complexes.
- Explore trans-effect, trans-influence, and their synthetic applications.
- Analyze electron transfer (inner/outer-sphere) using Marcus–Hush theory.

Bonding in Metal Complexes – II

- Learn free ion terms, electronic configurations, and microstates.
- Apply coupling schemes (L–S, j–j) and Hund's rules.
- Understand hole formalism and Racah parameters.
- Study weak crystal field effects and construct Orgel diagrams.
- Build theoretical background for interpreting electronic spectra.

Metal Clusters

- Understand metal–metal bonding and cluster stability.
- Apply Wade's and STYX rules to boranes and carboranes.
- Examine bonding in halide clusters.
- Relate cluster chemistry to reactivity, stability, and diversity.

Bio-coordination chemistry

- Explain the role of metal ions in biological systems and their physiological significance.
- Analyze the structural and functional aspects of oxygen transport proteins and photosynthetic systems.
- Evaluate the mechanisms of vitamin B6-dependent reactions in the presence of metal ions.

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Course Outcomes

After completing this course, students will be able to:

Reaction Mechanisms of Transition Metal Complexes

- Differentiate substitution reaction mechanisms (associative, dissociative, interchange).
- Explain acid and base hydrolysis in octahedral complexes and evidence for SN1CB mechanism.
- Analyze substitution in square-planar complexes and apply the trans-effect in synthesis of Pt(II) complexes.
- Compare inner- and outer-sphere electron transfer mechanisms and apply Marcus–Hush theory to cross reactions.

Bonding in Metal Complexes – II

- Calculate terms, states, and microstates for p- and d-electron configurations.
- Apply Hund's rules, spin–orbit coupling, and Racah parameters to predict electronic structures.
- Interpret Orgel diagrams for different dn configurations in octahedral and tetrahedral complexes.
- Correlate crystal field effects with energy ordering of electronic states.

Metal Clusters

- Classify metal carbonyl clusters into low- and high-nuclearity types using electron-counting rules.
- Explain metal–metal bonding, capping rules, and stereochemical non-rigidity in clusters.
- Apply Wade's and STYX rules to structures of boranes and carboranes.
- Explain structural aspects of halide clusters and metal–metal bonded systems.

Bio-coordination chemistry

- Describe the biological roles and physiological effects of metal ions in living systems.
- Interpret the structural and functional mechanisms of oxygen transport proteins and photosynthetic complexes.
- Assess metal-ion involvement in vitamin B6-mediated biochemical reactions and their mechanistic pathways.

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Organic chemistry

Course Objectives

Reaction Mechanisms-II

- To understand the concept of neighboring group participation (NGP) and its stereochemical implications.
- To study the generation, structure, stability, and reactivity of reactive intermediates like carbenes and nitrenes.
- To classify and analyze various molecular rearrangements involving electron-deficient carbon, nitrogen, oxygen, and base-catalyzed processes.
- To interpret stereospecific outcomes and apply mechanistic knowledge in organic synthesis.

Pericyclic Reactions

- To introduce the classification and mechanistic aspects of pericyclic reactions.
- To study electrocyclic, cycloaddition, sigmatropic, ene, and chelotropic reactions.
- To apply ATS, PMO, and FMO approaches to explain pericyclic reaction mechanisms.
- To frame and use Woodward–Hoffmann rules based on orbital symmetry.
- To solve problems using correlation diagrams and molecular orbital theory.

Photochemistry

- To introduce fundamental concepts of organic photochemistry and excited states.
- To study π–π^* and n–π^* transitions and their role in organic photoreactions.
- To explore cis–trans isomerization, photocycloadditions, photodimerizations, and rearrangements.
- To analyze Norrish Type I & II reactions, hydrogen abstraction, and Paternò–Büchi reactions.
- To understand the photochemistry of aromatic compounds and nitrites with mechanistic insights.

Reactive intermediates and Molecular rearrangements

- Explain the generation, structure, and reactivity of reactive intermediates such as carbenes, nitrenes, and free radicals.
- Classify and analyze various types of molecular rearrangements involving electron-deficient atoms and base-catalyzed mechanisms.
- Evaluate the stability and mechanistic pathways of rearrangement reactions to predict product formation.

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Course Outcomes

By the end of the course, students will be able to:

Reaction mechanism-II

- Explain the concept of NGP with stereospecific examples.
- Predict reaction mechanisms involving carbenes and nitrenes.
- Classify and describe major molecular rearrangements.
- Apply mechanistic reasoning to solve organic reaction problems.

Pericyclic reactions

- Identify and classify pericyclic reactions.
- Apply orbital symmetry rules to predict stereochemical outcomes.
- Use ATS, PMO, and FMO approaches for mechanistic interpretation.
- Construct correlation diagrams and solve reaction-based problems.
- Explain the significance of Woodward–Hoffmann rules in organic reactions.

Photochemistry

- Describe the excited states of organic molecules and their reactivity.
- Predict outcomes of photochemical reactions involving alkenes, dienes, and carbonyls.
- Analyze photorearrangements, photoreductions, and hydrogen abstraction reactions.
- Apply knowledge of Norrish and Paternò–Büchi reactions in synthetic contexts.
- Demonstrate understanding of photochemical principles in aromatic and heteroatom chemistry.

Reactive intermediates and Molecular rearrangements

- **Describe** the generation, structure, and reactivity of reactive intermediates such as carbenes, nitrenes, and free radicals.
- **Classify** and **analyze** molecular rearrangements involving electron-deficient carbon, nitrogen, and oxygen centers.
- **Evaluate** base-catalyzed rearrangement mechanisms and **predict** products based on structural and electronic factors.

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PHYSICAL CHEMISTRY

Course Objectives

Thermodynamics-II

- Explain the concepts of partial molar properties, chemical potential, and thermodynamic behavior of ideal and non-ideal solutions.
- Analyze the significance of fugacity, activity coefficients, and excess functions in non-ideal systems.
- Apply thermodynamic principles to derive and interpret colligative properties and solve related numerical problems.

Photochemistry –I

- Understand the principles of molecular electronic transitions, excited state lifetimes, and quantum yield determination.
- Apply photophysical and photochemical concepts to interpret energy diagrams and reaction kinetics.
- Analyze advanced techniques such as photosensitization, quenching, and flash photolysis in fast photochemical reactions.

Quantum Chemistry – II

- To develop understanding of hydrogen atom wave functions and quantum numbers.
- To apply approximate methods (variation method) to many-electron systems.
- To introduce molecular orbital (MO) and valence bond (VB) theories.
- To construct MO diagrams and describe bonding in diatomic molecules.

Solid State Chemistry

- To study electronic properties of solids and band theory.
- To explore concepts of superconductivity and high-temperature superconductors.
- To introduce nanoscience and nanotechnology.
- To learn preparation and characterization methods of nanoparticles.
- To study applications of nanomaterials in science and technology.

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Course Outcomes

Thermodynamics-II

- **Interpret** partial molar properties, chemical potential, and thermodynamic behavior of ideal and non-ideal solutions.
- **Examine** the role of fugacity, activity coefficients, and excess functions in describing non-ideal solution behavior.
- **Utilize** thermodynamic principles to derive colligative properties and solve related problems involving solution composition.

Photochemistry –I

- **Explain** molecular electronic transitions, excited state lifetimes, and quantum yield determination methods.
- **Analyze** photophysical processes, energy level diagrams, and kinetics of unimolecular reactions.
- **Evaluate** photochemical mechanisms including photosensitization, quenching, and fast reaction techniques like flash photolysis.

Quantum Chemistry – II

Students will be able to:

- Solve Schrödinger's equation for hydrogen-like atoms and interpret orbitals.
- Apply the variation method to approximate solutions of quantum systems.
- Construct MO diagrams for H_2^+ and H_2 using LCAO.
- Compare MO and VB approaches to chemical bonding.
- Interpret radial distribution, polar plots, and orbital shapes.

Solid State Chemistry

Students will be able to:

- Explain band structures of metals, insulators, and semiconductors.
- Describe the Meissner effect, BCS theory, and high-Tc superconductors.
- Explain preparation methods of nanoparticles (sol–gel, CVD, thermolysis).
- Interpret characterization data from XRD, SEM, TEM, and AFM.
- Relate nanoparticle properties to their applications.

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Analytical Techniques

Course Objectives

Electro and Thermal Analytical Techniques

- To understand principles and classification of electroanalytical techniques.
- To study instrumentation and applications of polarography, amperometry, and cyclic voltammetry.
- To apply electroanalytical methods for qualitative and quantitative analysis.
- To learn principles and applications of thermal analysis methods (TGA, DTA, DSC).

NMR-II

- To introduce multinuclear (^{19}F, ^{31}P) and solid-state NMR techniques.
- To analyze first-order and complex NMR spectra and simplify using advanced methods.
- To study applications of lanthanide shift reagents, CSAs, and NOE.
- To explore applications of ^{19}F and ^{31}P NMR in organic and inorganic systems..

Mass Spectrometry

- To introduce principles and instrumentation of electron ionization (EI) mass spectrometry.
- To study fragmentation patterns and rules (even-electron, nitrogen rule, isotopic peaks).
- To explore advanced ionization methods (CI, API, SIMS, ESI, MALDI).
- To understand coupled techniques (GC-MS, LC-MS) for structural analysis.

Photoelectron & ESR spectroscopy

- Understand the principles, instrumentation, and applications of photoelectron spectroscopy including UPS, XPS, and Auger techniques.
- Interpret vibrational spectral data, binding energies, and molecular orbital characteristics of simple molecules.
- Analyze ESR spectral parameters such as Lande's factor, hyperfine coupling, and zero-field splitting to study free radicals and transition metal complexes.

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Course Outcomes

Electro and Thermal Analytical Techniques

Students will be able to:

- Explain polarographic methods and analyze mixtures of inorganic/organic compounds.
- Apply amperometric titrations for determination of ions and complexes.
- Use cyclic voltammetry for studying redox behavior and HOMO-LUMO levels.
- Interpret thermal analysis data (TGA, DTA, DSC) for characterization of materials.

NMR-II

Students will be able to:

- Interpret multinuclear and solid-state NMR spectra.
- Apply shift reagents and chiral solvents for stereochemical analysis.
- Explain and analyze NOE and fluxional behavior in molecules.
- Utilize ^{19}F and ^{31}P NMR in structural determination of compounds.

Mass Spectrometry

Students will be able to:

- Interpret mass spectra and deduce molecular formula using isotopic and fragmentation patterns.
- Identify characteristic rearrangements (McLafferty, retro Diels–Alder, ortho effect).
- Explain principles of high-resolution MS and ionization techniques.
- Apply GC-MS and LC-MS for complex mixture analysis.

Photoelectron & ESR spectroscopy

- Explain the principles, instrumentation, and applications of photoelectron spectroscopy techniques such as UPS, XPS, and Auger spectroscopy.
- Interpret photoelectron spectra of simple molecules to determine binding energies, vibrational structures, and molecular orbital characteristics.
- Analyze ESR spectral parameters including g-values, hyperfine coupling, and zero-field splitting to study free radicals and transition metal complexes.

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