Semester	**8**
Programme	**CHEMISTRY**
Course	**MAJOR (COURSEWORK)**
Paper Code	
Credits	**4 (THEORY: 4)**
Hours/week	**6 (THEORY: 4)**
Category: Core/MDC/SEC/VEC	**CORE**
Theory/Practical/Composite	**COMPOSITE**
Number of Modules	**3**
Syllabus	**Theory:** **Paper 1** **Group A** 1. RCM reactions involving sugar derivatives 2. Application of Click reaction involving sugar derivatives **Group B** Fluorescence spectroscopy & Medicinal chemistry- problems in organic synthesis : Introduction to Fluorescence spectroscopy, Molecular fluorescence as an analytical tools, Characteristics of Fluorescence emission, Factors affecting Fluorescence chemosensors, Basic principles and types of chemosensors, Various mechanistic pathways for Fluorescence signalling, Fluorescent molecular sensors of ions and molecules. Synthesis of few Medicinal compounds and their importances. **Paper 2** **Group A** Foundations of the Nanoscale: The Nanoscale: Definition of nanotechnology and spatial dimensions. Classification: 0D (quantum dots), 1D (nanowires), 2D (thin films). Density of States (DOS): Mathematical derivation of DOS across dimensions. Scaling Laws: Why small changes mean big differences. Surface-to-Volume Ratio: Geometric consequences of shrinking materials. Surface Physics: Broken symmetry, dangling bonds, coordination numbers. Particle in a Box: Infinite potential well model for nanoparticles under periodic potential: Drude model modifications for confined electrons Bandgap Engineering: Shift from continuous bands to discrete levels. Quantum Confinement: Bandgap tuning and quantum dots. Exciton Physics: Wannier-Mott excitons and the effective mass approximation. Blue-Shift Phenomenon: Analytical calculation of optical absorption shifts. Optical Properties: Surface Plasmon Resonance (SPR) in metals: Coherent oscillations in metallic nanoparticles.

	Thermodynamics: Melting point depression in nano-sized systems. Radiative Decay: Luminescence, quantum yield, and lifetime modifications. Top-Down Methods: Ball milling, lithography, and laser ablation. Bottom-Up Methods: Sol-gel, Chemical Vapor Deposition (CVD). Green Synthesis: Using biological extracts for eco-friendly synthesis. Self-Assembly: Thermodynamic driving forces behind molecular alignment. **Group B** The Fundamental Principles of EPR: Electron Spin and the Zeeman Effect, The g-Factor and Spin-Orbit Coupling, Signal Characteristics, Theoretical Basis of Hyperfine Coupling **Group C** Applications and Problem Solving in EPR: Decoding Hyperfine Splitting Patterns, EPR of Transition Metal Complexes, Spectral Analysis **Paper 3** **Group A** Advanced NMR Spectroscopy: Application of 1 H- 1 H COSY, 1 H- 13 C HETCOR, HMBC, HMQC, HSQC, TOCSY, NOESY, DOSY in structure elucidation of organic compounds, and reaction monitoring. Structural elucidation of unknown organic compounds involving various spectroscopic data. **Group B** Electrochemistry and its applications: Electrochemical instrumentation and techniques, Potentiostatic and galvanostatic experiments including Cyclic voltammetry, chronoamperometry, chronopotentiometry and their applications, Kinetics of electrode reactions and electrochemical reactions, Butler-Volmer Equation, Tafel Equation, Overpotential, Electrocatalysis and applications, Electrochemistry of surfaces and films and applications including Electrochemical Impedance Spectroscopy, Analytical electrochemistry
Course Overview	**Theory:** The course represents an advanced capstone level, covering organic synthesis (carbohydrates/medicinal), nanostructured materials, and advanced analytical instrumentation (NMR, EPR, Electrochemistry). Paper 1 (Synthesis & Spectroscopy): Focuses on Ring-Closing Metathesis (RCM) and "Click" chemistry involving sugar derivatives, alongside fluorescence spectroscopy. It explores the design of molecular chemosensors and the synthesis of medicinal compounds. Paper 2 (Nanotechnology & EPR): Provides a deep dive into the

	physics of the nanoscale (DOS, scaling laws, particle-in-a-box models) and advanced synthesis methods (Sol-gel, CVD, Green Synthesis). This paper also covers the theoretical and practical framework of Electron Paramagnetic Resonance (EPR) spectroscopy, including Zeeman effects and hyperfine coupling patterns in transition metal complexes. Paper 3 (Advanced NMR & Electrochemistry): Delivers rigorous training in multi-dimensional NMR techniques (COSY, HETCOR, HMBC, NOESY) for complex structure elucidation. It also covers modern electrochemical techniques, including Cyclic Voltammetry (CV), Butler-Volmer kinetics, and Electrochemical Impedance Spectroscopy (EIS).
Course Outcomes	Upon successful completion of this advanced course, the student will be able to: **CO1 [Organic Synthesis]:** Design and execute synthetic routes for sugar-based derivatives and medicinal compounds using RCM and Click chemistry protocols. **CO2 [Fluorescence Analysis]:** Analyze molecular fluorescence mechanisms and factors affecting chemosensor efficacy for analytical sensing applications. **CO3 [Nanomaterials Physics]:** Evaluate the geometric and electronic consequences of the nanoscale (DOS, Surface-to-volume ratio) and apply infinite potential well models to nanoparticles. **CO4 [EPR Spectroscopy]:** Interpret EPR spectra, including hyperfine splitting patterns, to determine oxidation states and geometric environments of transition metal complexes. **CO5 [Advanced NMR]:** Apply 2D NMR techniques (COSY, HMBC, NOESY, etc.) to successfully elucidate the structure of unknown complex organic molecules. **CO6 [Advanced Electrochemistry]:** Conduct and interpret advanced electrochemical measurements (CV, chronoamperometry, EIS) to study reaction kinetics and interfacial properties. **CO7 [Synthetic Fabrication]:** Apply diverse methodologies such as Sol-gel, CVD, and Green synthesis to fabricate controlled nanostructures. **CO8 [Data-Driven Research]:** Integrate multiple analytical data streams (NMR, EPR, Electrochemistry) to conduct a comprehensive structural and kinetic investigation of chemical systems.
Program Outcomes	**PO1: Disciplinary Knowledge:** Mastery of complex chemical phenomena, including frontier research areas in nanotechnology, advanced synthesis, and quantum-based spectroscopic techniques.

	PO2: Analytical & Research Proficiency: Ability to interpret complex spectral data (NMR, EPR, Fluorescence) and derive structural information from unknown organic compounds. **PO3: Advanced Experimental Competence:** Proficiency in cutting-edge laboratory techniques, including nano-synthesis, potentiostatic/galvanostatic methods, and modern synthetic protocols. **PO4: Problem Solving & Computational Thinking:** Capacity to apply mathematical models (e.g., DOS, Butler-Volmer equation, particle-in-a-box) to predict and explain chemical behavior. **PO5: Interdisciplinary Insight:** Ability to bridge chemical synthesis with medicine, biology, and materials science, particularly in sensor development and catalytic applications. **PO6: Scientific Communication & Documentation:** Competence in drafting research-level reports, analyzing complex data-sets, and communicating findings through professional and scholarly channels. **PO7: Ethics, Safety & Professionalism:** Strict adherence to ethical research standards, safe handling of hazardous instrumentation/reagents, and data integrity in the laboratory.

CO #	Core Curriculum Domain	Bloom's Taxonomy (K-Level)	Mapped POs
CO1	RCM & Click Chemistry Synthesis	**K3** (Apply), **K6** (Create)	PO1, PO3
CO2	Fluorescence Spectroscopy	**K4** (Analyze)	PO1, PO5
CO3	Nanoscale Physics & Modeling	**K4** (Analyze)	PO1, PO4
CO4	EPR & Zeeman Effect	**K5** (Evaluate)	PO2, PO4
CO5	Multi-dimensional NMR	**K4** (Analyze), **K5** (Evaluate)	PO2, PO6
CO6	Electrochemical Techniques	**K3** (Apply), **K4** (Analyze)	PO3, PO4
CO7	Nanostructure Fabrication	**K3** (Apply), **K6** (Create)	PO3, PO5
CO8	Integrated Research Interpretation	**K6** (Create)	PO6, PO7

Reading/Reference Lists	**Theory:**	
Evaluation		

Paper Structure for Theory Semester Exam	