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| Semester | **3** |
| Programme | **CHEMISTRY** |
| Course | **MINOR (GENERAL CHEMISTRY 3)** |
| Paper Code | **B2CH230312T/ B2CH230312P** |
| Credits | **4 (THEORY: 3 PRACTICAL: 1)** |
| Hours/week | **5 (THEORY: 3 PRACTICAL: 2)** |
| Category: Core/MDC/SEC/VEC | **CORE** |
| Theory / Practical / Composite | **COMPOSITE** |
| Number of Modules | **4 (THEORY: 3; PRACTICAL: 1)** |
| Syllabus | **Theory:**<br><br>**Group A**<br>**Module 1: Carbonyl Compounds (12 Lectures)**<br>Aldehydes and Ketones: General properties of aldehydes and ketones; Reactions: with HCN, ROH, $NaHSO_3$, $NH_2$-G derivatives and with Tollens' and Fehling's reagents; iodoform test; aldol condensation (with mechanism); Claisen-ester condensation, Cannizzaro reaction (with mechanism), Tischenko reaction (with mechanism), Perkin reaction, Wittig reaction, benzoin condensation; Clemmensen reduction, Wolff- Kishner reduction and Meerwein-Pondorff- Verley (MPV) reduction. Preparations and reactions of carboxylic acids, esters, amides, nitriles etc.<br><br>**Group B**<br><br>**Module 2: Introduction to Spectroscopy (12 Lectures)**<br><br>1. Schrödinger equation as a proposal of Quantum Mechanics<br>2. Conditions of acceptable solutions<br>3. Particle in a one dimensional box problem: zero potential inside and infinite potential at boundary and beyond<br>4. General solution: appearance of quantum number as a requirement of mathematical solution<br>5. Pictorial representation of acceptable solution, ortho-normality criteria<br>6. Energy expression: energy quantization<br>7. Extension to three dimensional box<br>8. Transitions between different states. |

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| | 9. Energy expression of rigid rotor and simple harmonic oscillator under Born-Oppenheimer limit, selection rules<br>10. Physical properties from as outcomes of spectrum<br>11. Breakdown of simple harmonic model: Morse potential<br>12. Energy expression and spectra under anhermonic oscillator model<br>13. Breakdown of Born-Oppenheimer approximation and introduction to vibronic spectra<br><br>**Module 3: Ionic Equilibrium (12 Lectures)**<br><br>1. Acid-base equilibria in aqueous solution (Proton transfer equilibria in water),<br>2. pH,<br>3. Buffer.<br>4. Acid-base neutralisation curves;<br>5. Indicator, choice of indicators.<br>6. Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides.<br><br>**Practical:**<br><br>**Qualitative Analysis of Single Solid Organic Compounds**<br><br>1. Detection of special elements (N, S, Cl) by Lassaigne's test<br>2. Solubility and classification (solvents: $H_2O$, 5% HCl, 5% NaOH and 5% $NaHCO_3$)<br>3. Melting point of the given compound.<br>4. Detection of the following functional groups by systematic chemical tests:Nitrogenous functional groups:Aromatic amino ($-NH_2$), Aromatic nitro ($-NO_2$), Amido ($-CONH_2$, including imide).Non-nitrogenous functional groups: Carboxylic acid (-COOH), Phenolic -OH, Carbonyl (-CHO and >C=O). |
| Course Overview | **General Chemistry 3 (B2CH230312T / B2CH230312P)** is a second-year undergraduate composite chemistry course designed to integrate synthetic molecular transformations with quantum mechanical principles and physical equilibrium states.<br>• **Carbonyl Compounds & Functional Derivatives (Module I):** Covers the electronic properties, nucleophilic addition pathways, and complex name reactions of aldehydes and ketones. It teaches step-by-step condensation mechanisms (Aldol, Claisen-ester, Cannizzaro, Tischenko, Perkin, Wittig, Benzoin), comparative functional reduction strategies (Clemmensen, Wolff-Kishner, MPV), and the preparation and reactivity profiles of carboxylic acids, esters, amides, and nitriles.<br>• **Introduction to Spectroscopy & Quantum Mechanics (Module II):** Explores the physical criteria for |

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| | wavefunctions and the Schrödinger equation using the Particle-in-a-Box model (1D and 3D) to explain energy quantization and orthonormality. It expands these concepts to molecular transitions via rigid rotor and harmonic/anharmonic oscillator models under the Born-Oppenheimer limit, tracking Morse potentials and vibronic breakdowns.<br>• **Ionic Equilibrium & Solution Dynamics (Module III):** Investigates proton transfer equilibria in water, focusing on pH scales, buffer capacity, neutralization curves, indicators, the solubility product principle ($K_{sp}$), and the common ion effect applied to qualitative separation schemes.<br>• **Qualitative Organic Analysis Practical (Module IV):** Cultivates systematic laboratory skills through element detection (Lassaigne's test), solubility testing, and functional group classification of unknown single solid organic matrices. |
| Course Outcomes (CO) | Upon successful completion of this course, students will be able to:<br><br>**CO1 [Carbonyl Reactivity & Nucleophilic Additions]**: Analyze the polarization and electronic environment of the carbonyl group to explain nucleophilic additions (HCN, ROH, $NaHSO_3$, and $NH_2$-G derivatives); interpret diagnostic colorimetric assays (Tollens', Fehling's reagents, and iodoform test).<br><br>**CO2 [Mechanistic Condensation & Rearrangement Pathways]**: Formulate explicit step-by-step mechanistic pathways for carbon-carbon bond-forming named reactions, including Aldol, Claisen-ester, Cannizzaro, Tischenko, Perkin, Wittig, and Benzoin condensations.<br><br>**CO3 [Chemoselective Reductions & Carboxylic Acid Derivatives]**: Differentiate between functional reduction pathways (Clemmensen, Wolff-Kishner, and MPV reduction) based on substrate limitations; outline synthetic routes for preparing carboxylic acids, esters, amides, and nitriles.<br><br>**CO4 [Quantum Operators & Particle-in-a-Box Models]**: Set up and solve the Schrödinger equation for a particle trapped in one-dimensional and three-dimensional potential boxes; apply spatial boundary conditions to derive quantized energy states; evaluate wavefunction orthonormality criteria.<br><br>**CO5 [Diatomic Spectroscopic Models & Transitions]**: Evaluate the rigid rotor and linear harmonic oscillator models under the Born-Oppenheimer limit; determine the impacts of anharmonicity via the Morse potential; apply selection rules to predict rotational, vibrational, and vibronic transitions; interpret breakdown of Born-Oppenheimer approximation.<br><br>**CO6 [Aqueous Acid-Base Equilibria & Neutralization Dynamics]**: Quantify proton transfer equilibria in aqueous solutions to calculate pH and buffer performance limits; construct acid-base |

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| | neutralization curves; select appropriate indicators using transition intervals.<br><br>**CO7 [Solubility Product Principles & Ionic Separations]**: Apply the solubility product constant (Ksp) and the common ion effect to calculate precipitation thresholds; design analytical schemes for separating common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates, and halides.<br><br>**CO8 [Qualitative Organic Analysis Operations]**: Execute systematic laboratory operations to analyze a single unknown solid organic compound by performing Lassaigne's element tests (N, S, Cl), solubility classification ($H_2O$, 5% HCl, 5% NaOH, 5% $NaHCO_3$), melting point determination, and functional group detection. |
| Program Outcomes (POs) | **PO1: Fundamental Knowledge:** Demonstrate a comprehensive understanding of core concepts in chemistry, including organic, inorganic, physical, analytical, and biochemistry.<br>**PO2: Laboratory Skills:** Acquire hands-on experience in laboratory techniques and instrumentation, applying safety protocols and proper methodologies to conduct experiments and analyse results.<br>**PO3: Problem Solving:** Develop critical thinking and problem-solving skills by applying chemical principles to real-world scenarios, including the ability to design experiments and interpret data.<br>**PO4: Research Competency:** Engage in independent and collaborative research projects, employing scientific methods to formulate hypotheses, conduct experiments, and communicate findings effectively.<br>**PO5: Interdisciplinary Applications:** Understand the interdisciplinary nature of chemistry, exploring its applications in fields such as medicine, environmental science, materials science, and nanotechnology.<br>**PO6: Communication Skills:** Effectively communicate scientific information, both verbally and in written form, to diverse audiences, demonstrating the ability to present complex ideas clearly and concisely.<br>**PO7: Ethics and Sustainability:** Recognize the ethical implications and responsibilities of scientific research and practice in chemistry, emphasizing the importance of sustainability and environmental stewardship in chemical practices. |

| CO # | Core Curriculum Domain | Bloom's Taxonomy K-Level | Mapped POs | Pedagogical Justification for K-Level & PO Selection |
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| **CO 1** | **Carbonyl Reactivity & Additions** | **K2 (Understand)**<br><br>**K4 (Analyze)** | **PO1, PO3** | **Students understand electrophilic centers of carbonyls and analyze diagnostic testing profiles based on structural behavior; essential for fundamental knowledge and problem-solving.** |

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| **CO 2** | **Named Condensation Mechanics** | **K4 (Analyze)** | **PO1, PO3** | **Students break down multi-stage transformations into discrete steps, tracking electron pair movements and intermediate states; requires high-level analytical reasoning.** |
| **CO 3** | **Chemoselective Reductions & Derivatives** | **K3 (Apply)** | **PO1, PO3** | **Students apply functional group transformation rules to choose appropriate reducing agents and map synthesis of acid derivatives; demonstrates application of fundamental knowledge.** |
| **CO 4** | **Quantum Mechanics & Wave Boundaries** | **K3 (Apply)**<br><br>**K4 (Analyze)** | **PO1, PO3, PO4, PO5** | **Students apply operators to boundary conditions and analyze how mathematical requirements generate discrete quantum constraints; bridges fundamental knowledge with research competency.** |
| **CO 5** | **Diatomic Spectroscopic Transitions** | **K4 (Analyze)** | **PO1, PO3, PO4, PO5** | **Students analyze how physical molecular features are extracted from spectra when ideal harmonic and Born-Oppenheimer models break down; demonstrates interdisciplinary applications.** |
| **CO 6** | **Acid-Base Equilibria & Neutralization** | **K3 (Apply)** | **PO1, PO3, PO6, PO7** | **Students apply equilibrium algebra to neutralize mixtures, evaluate buffer thresholds, and select appropriate chemical indicators; develops problem-solving and communication skills.** |
| **CO 7** | **Solubility Product & Ionic Separations** | **K4 (Analyze)** | **PO1, PO3, PO6, PO7** | **Students analyze complex ionic mixtures mathematically to predict conditions for selective chemical precipitation; connects to** |

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| | | | | **ethical implications of separation techniques.** |
| **CO 8** | **Qualitative Wet Laboratory Analysis** | **K3 (Apply)**<br><br>**K4 (Analyze)** | **PO2, PO4, PO6** | **Students execute bench operations for element assays, compile data from selective solubilities, and identify unknown organic structures; demonstrates laboratory skills, research competency, and communication.** |

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| Reading/Reference Lists | 1. Atkins' Physical Chemistry, James Keeler, Julio de Paula, Peter Atkins, 12th edition, OUP<br>2. Physical Chemistry, T. Engel, P. Reid, 3rd edition, Pearson Education India<br>3. General and Inorganic Chemistry, Volume 1, R. P. Sarkar, New Central Book Agency; 3rd Revised edition.<br>4. Physical Chemistry, P. C. Rakshit, 5th edition, Sarat Book House<br>5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.<br>6. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).<br>Practical:<br>1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta<br>2. Nad, Mahapatra, Ghosal-Practical Chemistry | |
| Evaluation | Theory: 60<br>Internal: 15 (CIA: 10; Other form of Assessment: 2; Attendance: 3)<br>Semester Exam:45 (Gr. A: 15; Gr. B:30) | Practical: 40<br>CA:38; Attendance: 2 |
| Paper Structure for Theory Semester Exam | Gr. A: Attempt ONE out of TWO questions of 15 Marks each<br>Gr. B: Attempt TWO out of THREE questions of 15 marks each | |