Semester	**5**
Programme	**CHEMISTRY**
Course	**MAJOR (ORGANIC CHEMISTRY 4)**
Paper Code	**C3CH230512T/ C3CH230512P**
Credits	**4 (THEORY: 3 + PRACTICAL: 1)**
Hours/week	**6 (THEORY: 3 + PRACTICAL: 3)**
Category: Core/MDC/SEC/VEC	**CORE**
Theory/Practical/Composite	**COMPOSITE**
Number of Modules	**03**

Syllabus	**Module I: Spectroscopy-I (12 Lectures)** UV Spectroscopy: introduction;types of electronic transitions, end absorption; transition dipole moment and allowed/forbidden transitions; chromophores and auxochromes; Bathochromic and Hypsochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); extended conjugated systems (dienes, aldehydes and ketones); relative positions of λmax considering conjugative effect, steric effect, solvent effect, effect of pH; effective chromophore concentration: keto-enol systems; benzenoid transitions. IR Spectroscopy: introduction;modes of molecular vibrations(fundamental and non-fundamental); IR active molecules; application of Hooke's law, force constant; fingerprint region and its significance; effect of deuteration; overtone bands; vibrational coupling in IR; characteristic and diagnostic stretching frequencies of C-H, N-H, O-H, C-O, C-N, C-X, C=C (including skeletal vibrations of aromatic compounds), C=O, C=N, N=O, C≡C, C≡N; characteristic/diagnostic bending vibrations are included; factors affecting stretching frequencies: effect of conjugation, electronic effects, mass effect, bond multiplicity, ring-size, solvent effect, H-bonding on IR absorptions; application in functional group analysis. **Module II: Rearrangements (12 Lectures)** Mechanism with evidence and stereochemical features for the following Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, benzil-benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement. Rearrangement to electron-deficient nitrogen: rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann. Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, cumenehydroperoxide-phenol rearrangement and Dakin reaction. Aromatic rearrangements: Migration from oxygen to ring carbon: Fries rearrangement and Claisen rearrangement. Migration from nitrogen to ring carbon: Hofmann-Martius rearrangement, Fischer-Hepp rearrangement, N-azo to C-azo rearrangement,

	Bamberger rearrangement, Orton rearrangement and benzidine rearrangement. **Module III: Nitrogen compounds (12 Lectures)** Amines: Aliphatic & Aromatic: preparation, separation (Hinsberg's method) and identification of primary, secondary and tertiary amines; reaction (with mechanism): Eschweiler–Clarke methylation,diazo coupling reaction, Mannich reaction; formation and reactions of phenylenediamines, diazomethane and diazoacetic ester. Nitro compounds (aliphatic and aromatic): preparation and reaction (with mechanism): reduction under different conditions; Nef carbonyl synthesis, Henry reaction and conjugate addition of nitroalkane anion. Alkylnitrile and isonitrile: preparation and reaction (with mechanism): Thorpe nitrile condensation, von Richter reaction. Diazonium salts and their related compounds: reactions (with mechanism) involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp-Klingermann. **Practical** a) Synthesis of drugs, industrially important organic compounds 1. Synthesis of paracetamol/ibuprofen 2. Synthesis of sulfanilamide. 3. Synthesis of aspirin. 4. Synthesis of tetrahydrocarbazole from phenyl hydrazine and cyclohexanone. 5. Synthesis of methyl orange. b) Estimation of organic compounds and drugs 1. Estimation of aniline/phenol 2. Estimation of vitamin-C/paracetamol. 3. Estimation of glucose/sucrose 4. Estimation of formaldehyde.
Course Overview	**Theory:** To have knowledge about i) Spectroscopy of organic molecules ii) Rearrangement reactions iii) Reaction and synthesis of Nitrogen compounds **Practical:** Synthesis of drugs, industrially important organic compounds

Course Outcomes	Upon successful completion of this course, students will be able to: CO1: Explain the fundamental principles of electronic (UV) and vibrational (IR) spectroscopy, including transitions, dipole moments, selection rules, and modes of molecular vibration. CO2: Apply Hooke’s Law to estimate IR stretching frequencies and analyze the shifts in absorption peaks (λmax and wavenumber) caused by conjugation, steric constraints, electronic effects, ring strain, hydrogen bonding, and solvent choices. CO3: Dedduce functional groups and decipher structural features of unknown organic molecules by analyzing the fingerprint and diagnostic regions of IR spectra alongside UV chromophore profiles. CO4: Diagram the reaction mechanisms and stereochemical requirements of molecular rearrangements migrating to electron-deficient sites (carbon, nitrogen, and oxygen). CO5: Predict the migration outcomes and products of intramolecular and intermolecular rearrangements involving aromatic rings (e.g., Fries, Claisen, Hofmann-Martius, and benzidine rearrangements). CO6: Formulate chemical protocols to differentiate, separate (via Hinsberg’s method), and synthesize primary, secondary, and tertiary aliphatic or aromatic amines. CO7: Categorize and analyze the mechanisms of synthetic transformations involving nitroalkanes, alkylnitriles, isonitriles, and diazomethane intermediates (e.g., Nef synthesis, Henry reaction, Thorpe condensation). CO8: Design multi-step organic pathways utilizing the high synthetic versatility of diazonium salts, diazoacetic esters, and associated named reactions (e.g., Gomberg, Meerwein, Japp-Klingermann). CO9: Formulate safe operational strategies for managing highly toxic or explosive organic reagents (e.g., diazomethane, nitriles) while effectively synthesizing, troubleshooting, and interpreting structural data within the laboratory.
Program Outcomes	**PO1.** Fundamental Knowledge: Demonstrate a comprehensive understanding of core concepts in chemistry, including organic, inorganic, physical, analytical, and biochemistry. **PO2.** Laboratory Skills: Acquire hands-on experience in laboratory techniques and instrumentation, applying safety protocols and proper methodologies to conduct experiments and analyse results. **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. **PO4.** Research Competency: Engage in independent and collaborative research projects, employing scientific methods to formulate hypotheses, conduct experiments, and communicate findings

	effectively. **PO5.** Interdisciplinary Applications: Understand the interdisciplinary nature of chemistry, exploring its applications in fields such as medicine, environmental science, materials science, and nanotechnology. **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. **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.

Module	Course Outcome (CO)	Cognitive Domain (Bloom's K-Values)	Mapped Program Outcomes (POs)
Module I: Spectroscopy-I	**CO1:** Explain the fundamental principles of electronic (UV) and vibrational (IR) spectroscopy, including transitions, dipole moments, selection rules, and modes of molecular vibration.	**K2** (Understanding)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO2: Apply Hooke's Law to estimate IR stretching frequencies and analyze the shifts in absorption peaks (λ_{max} and wavenumber) caused by conjugation, steric constraints, electronic effects, ring strain, hydrogen bonding, and solvent choices.	**K3** (Applying) **K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO3: Dedduce functional groups and decipher structural features of unknown organic molecules by analyzing the fingerprint and diagnostic regions of IR spectra alongside UV	**K4** (Analyzing)	**PO3:** Problem Solving **PO5:** Modern Tool Usage

	chromophore profiles.		
Module II: Rearrangements	**CO4:** Diagram the reaction mechanisms and stereochemical requirements of molecular rearrangements migrating to electron-deficient sites (carbon, nitrogen, and oxygen).	**K2** (Understanding) **K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO5: Predict the migration outcomes and products of intramolecular and intermolecular rearrangements involving aromatic rings (e.g., Fries, Claisen, Hofmann-Martius, and benzidine rearrangements).	**K3** (Applying)	**PO1:** Core Knowledge **PO3:** Problem Solving
Module III: Nitrogen compounds	**CO6:** Formulate chemical protocols to differentiate, separate (via Hinsberg's method), and synthesize primary, secondary, and tertiary aliphatic or aromatic amines.	**K3** (Applying) **K6** (Creating)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO7: Categorize and analyze the mechanisms of synthetic transformations involving nitroalkanes, alkylnitriles, isonitriles, and diazomethane intermediates (e.g., Nef synthesis, Henry reaction, Thorpe condensation).	**K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving

	CO8: Design multi-step organic pathways utilizing the high synthetic versatility of diazonium salts, diazoacetic esters, and associated named reactions (e.g., Gomberg, Meerwein, Japp-Klingermann).	**K4** (Analyzing) **K6** (Creating)	**PO3:** Problem Solving **PO4:** Research Competency
Cross-Cutting / All Modules	**CO9:** Formulate safe operational strategies for managing highly toxic or explosive organic reagents (e.g., diazomethane, nitriles) while effectively synthesizing, troubleshooting, and interpreting structural data within the laboratory.	**K5** (Evaluating) **K6** (Creating)	**PO2:** Laboratory Skills **PO6:** Communication Skills **PO7:** Ethics and Sustainability

Reading/Reference Lists	**Theory:**

	1. Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012. 2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003. 3. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited. 4. Carey, F. A. &Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012. 5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008. 6. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 7. Finar, I. L. Organic Chemistry (Volume 1) Pearson Education. 8. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc. 9. Kalsi, P. S. Spectroscopy of Organic Compounds, New Age International (P) Limited, 2005. 10. Kemp, W. Organic Spectroscopy, Palgrave Macmillan, 1991. 11. Norman, R., Principles of Organic Synthesis, Springer, 1993. 12. March, J., Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Wiley; 4th edition, 2006. **Practical** 1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors. 2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003. 3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009). 4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. &Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012). 5. Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). 6. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.	
Evaluation	Theory: 60	Practical: 40 CA: 38; Attendance:2

	Internal: 15 (CIA: 10; Other form of Assessment: 2; Attendance: 3) Semester Exam: 45	
Paper Structure for Theory Semester Exam	Answer THREE out of FOUR questions of 15 marks each.	