Semester	**6**
Programme	**CHEMISTRY**
Course	**MAJOR (ORGANIC CHEMISTRY 5)**
Paper Code	**C3CH230612T / C3CH230612P**
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	**3**
Syllabus	**Module I: Organic Synthesis with retrosynthetic approach (12 Lectures)** *Retrosynthetic analysis:* disconnections; synthons, donor and acceptor synthons; natural reactivity and *umpolung*; latent polarity in bifunctional compounds: consonant and dissonant polarity; illogical electrophiles and nucleophiles; synthetic equivalents; functional group interconversion and addition (FGI and FGA); C-C disconnections and synthesis: one- group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl); protection-deprotection strategy (alcohol, amine, carbonyl, acid). *Strategy of ring synthesis:* thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique. *Asymmetric synthesis*: stereoselective and stereospecific reactions; diastereoselectivity and enantioselectivity (only definition); enantioselectivity: kinetically controlled MPV reduction; diastereoselectivity: addition of nucleophiles to C=O adjacent to a stereogenic centre: Cram's and FelkinAnh models.

	Module II: Green chemistry and Chemistry of natural products (12 Lectures) Introduction, Definitions of Green Chemistry, Brief introduction of principles of Green Chemistry with examples, Special emphasis on atom economy, toxicity reduction, green solvents and subsequent use in organic synthesis, Green Chemistry and catalysis, reactions in micellar media, reactions in aqueous medium, reactions under solvent-free conditions, Enzyme catalyzed reactions, Examples of Green Synthesis/ Reactions: Aldol, Friedel- Crafts, Michael, Knoevenagel, Cannizzaro, Synthesis of adipic acid, catechol using green approach. *Natural products:* Alkaloids: Chemical transformation related to Morphine, Codeine; Synthesis of lead drug Naloxone, Naltrindole, Metopon. Terpenoids: Isoprene rule. Synthesis and physiological activity of representative examples of acyclic, monocyclic monoterpenoids. Steriods: Structural features, chemistry and physiological activity of steroids. **Module III: Dynamic stereochemistry (12 Lectures)** *Alicyclic compounds:* conformational analysis: Baeyer's strain theory, Cyclohexane: chair and boat conformations(symmetry elements and relative stabilities), symmetry properties and optical activity of mono and disubstituted cyclohexane systems; topomerisation: C_2-path and σ-path, relative stabilities of conformation in cyclohexane system considering steric and stereoelectronic effects- dipole-dipole

	interaction, anomeric effect, 2-alkyl ketone effect, 3-alkyl ketone effect, α-haloketone effect, $A^{1,2}$ strain; Conformation and reactivity in cyclohexane systems for the following reactions: hydrolysis of esters, elimination (E2, E1), nucleophilic substitution (S_N1, S_N2, S_Ni, NGP, merged substitution-elimination; rearrangement reactions; oxidation of cyclohexanol, reduction of cyclohexanone, esterification, lactonisation, epoxidation, pyrolytic *syn* elimination and fragmentation reactions; concept of I-strain. **Practicals** ***Multicomponent reactions & Multistep organic synthesis*** 1. Synthesis of 7-hydroxy-4-methyl coumarin from ethyl acetoacetate and resorcinol followed by nitration. 2. Synthesis of binol and its derivatives. 3. Synthesis of diphenyl acetic acid from benzoin. 4. Synthesis of quinoxaline derivative from benzoin. 5. Synthesis of glycine from phthalic anhydride. 6. Synthesis of 8-hydroxy quinolone and its derivative. 7. Multicomponent Biginelli reaction. 8. Microwave assisted synthesis of imidazoles from o-phenylene diamine and aldehydes.
Course Overview	***Theory:*** Students will have *knowledge about* i) Organic Synthesis with retrosynthetic approach ii) Study about the basics of green chemistry and the chemistry of some natural products ii) Dynamic stereochemistry of cyclic compounds ***Practical:*** The students will learn to do advanced multistep and multicomponent organic synthesis.

Course Outcomes	Upon successful completion of this course, students will be able to: CO1: Apply retrosynthetic principles (disconnections, synthons, functional group interconversions/additions) to break down complex molecules into logical starting materials, accounting for consonant/dissonant polarity and umpolung strategies. CO2: Design multi-step forward syntheses for 1,2- to 1,6-dioxygenated systems and cyclic compounds, integrating strategic protection-deprotection steps and high-dilution ring-closure techniques. CO3: Predict and rationalize the diastereoselective outcome of nucleophilic additions to chiral carbonyl compounds using Cram’s and Felkin-Anh models, while distinguishing between enantioselective and stereospecific processes. CO4: Evaluate and implement the 12 principles of Green Chemistry in organic transformations by prioritizing atom economy, toxicity reduction, green solvents, micellar media, and enzyme catalysis. CO5: Explain the physiological activities, structural features, and isoprene rules governing natural products, and outline the chemical transformations of alkaloids (morphine/codeine derivatives), terpenoids, and steroids. CO6: Formulate green, sustainable synthetic pathways for industrial targets and specialized pharmaceuticals, such as adipic acid, catechol, or lead-drug molecules (Naloxone, Naltrindole). CO7: Analyze the symmetry properties, topomerization pathways (C2 vs sigma-paths), and optical activity of mono- and disubstituted cyclohexane systems to determine conformer stabilities influenced by steric and stereoelectronic effects (e.g., anomeric, alkyl ketone, and □-haloketone effects). CO8: Evaluate the structural conformation of alicyclic frameworks to predict chemical reactivity, stereochemical outcomes, and reaction rates across substitutions, eliminations, rearrangements, and I-strain-driven processes. CO9: Plan, execute, and communicate a target-oriented synthetic pathway that blends retrosynthetic logic, safe handling of natural product derivatives, and green chemistry metrics within a laboratory framework.
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: Organic Synthesis with Retrosynthetic Approach	**CO1:** Apply retrosynthetic principles (disconnections, synthons, functional group interconversions/additions) to break down complex molecules into logical starting materials, accounting for consonant/dissonant polarity and umpolung strategies.	**K3** (Applying) **K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO2: Design multi-step forward syntheses for 1,2- to 1,6-dioxygenated systems and cyclic compounds, integrating strategic protection-deprotection steps and high-dilution ring-closure techniques.	**K6** (Creating)	**PO3:** Problem Solving **PO4:** Research Competency
	CO3: Predict and rationalize the diastereoselective	**K3** (Applying)	**PO1:** Core Knowledge

	outcome of nucleophilic additions to chiral carbonyl compounds using Cram’s and Felkin-Anh models, while distinguishing between enantioselective and stereospecific processes.	**K4** (Analyzing)	**PO3:** Problem Solving
Module II: Green Chemistry & Natural Products	**CO4:** Evaluate and implement the 12 principles of Green Chemistry in organic transformations by prioritizing atom economy, toxicity reduction, green solvents, micellar media, and enzyme catalysis.	**K3** (Applying) **K5** (Evaluating)	**PO1:** Core Knowledge **PO6:** Environment & Sustainability
	CO5: Explain the physiological activities, structural features, and isoprene rules governing natural products, and outline the chemical transformations of alkaloids (morphine/codeine derivatives), terpenoids, and steroids.	**K2** (Understanding) **K3** (Applying)	**PO1:** Core Knowledge **PO5:** Modern Tool Usage
	CO6: Formulate green, sustainable synthetic pathways for industrial targets and specialized pharmaceuticals, such as adipic acid, catechol, or lead-drug molecules (Naloxone, Naltrindole).	**K6** (Creating)	**PO3:** Problem Solving **PO6:** Environment & Sustainability

Module III: Dynamic Stereochemistry	**CO7:** Analyze the symmetry properties, topomerization pathways (C_2 vs sigma-paths), and optical activity of mono- and disubstituted cyclohexane systems to determine conformer stabilities influenced by steric and stereoelectronic effects (e.g., anomeric, alkyl ketone, and a-haloketone effects).	**K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO8: Evaluate the structural conformation of alicyclic frameworks to predict chemical reactivity, stereochemical outcomes, and reaction rates across substitutions, eliminations, rearrangements, and I-strain-driven processes.	**K4** (Analyzing) **K5** (Evaluating)	**PO1:** Core Knowledge **PO3:** Problem Solving
Cross-Cutting / Lab Links	**CO9:** Plan, execute, and communicate a target-oriented synthetic pathway that blends retrosynthetic logic, safe handling of natural product derivatives, and green chemistry metrics within a laboratory framework.	**K5** (Evaluating) **K6** (Creating)	**PO2:** Laboratory Skills **PO6:** Environment & Sustainability **PO7:** Communication & Ethics

Reading/Reference Lists	**Theory:** 1. Clayden, J., Greeves, N., Warren, S. *Organic Chemistry*, Second edition, Oxford University Press 2012. 2. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008. 3. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994. 4. Nasipuri, D. *Stereochemistry of Organic Compounds*, Wiley Eastern Limited. 5. Finar, I. L. *Organic Chemistry (Volume 1 & Volume 2)* Pearson Education. 6. Agarwal, O. P. Organic Chemistry Natural Products, Krishna Prakashan Media (P) Ltd, 2015. 7. Warren, S. & Wyatt, P. Organic Synthesis: The Disconnection Approach, Wiley, 2008. 8. Robinson, M. J. T., *Stereochemistry*, Oxford Chemistry Primer, Oxford University Press, 2005. 9. Kar, R. K. Fundamentals of Organic Synthesis the Retrosynthetic Analysis, New Central Book Agency, 2014. 10. Clark, J., MacQuarrie, D. *Handbook of Green Chemistry & Technology*, Blackwell Publishing, 2002. 11. Lindström, U. M. Organic Reactions in Water: Principles, Strategies and Applications, Blackwell Publishing, 2007. 12. Pelter, A. Natural Products. 13. Cordell, G. F. The Alkaloids, Academic Press Inc.

<table>
<tr><td></td><td colspan="2">14. Kalsi, P. S. Pharmaceutical medicinal & natural product chemistry, Alpha Science International Ltd.
<u>Practical</u>
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. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education.</td></tr>
<tr><td>Evaluation</td><td>Theory: 60
Internal: 15 (CIA: 10; Other form of Assessment: 2; Attendance: 3)
Semester Exam: 45</td><td>Practical: 40
CA: 38; Attendance:2</td></tr>
<tr><td>Paper Structure for Theory Semester Exam</td><td colspan="2">Answer THREE out of FOUR questions, of 15 marks each.</td></tr>
</table>