Semester	**4**
Programme	**CHEMISTRY**
Course	**MAJOR (ORGANIC CHEMISTRY 3)**
Paper Code	**C2CH230412T/ C2CH230412P**
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: Aromatic Substitution 12L** *Aromatic electrophilic substitution:* General mechanism and evidences in favour of it. ArES reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; chloromethylation reactions with mechanism. Orientation and reactivity towards electrophilic substitution for mono-substituted aromatic compounds. Named reactions based on ArES: Gatterman-Koch, Gatterman, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt. *Ipso* substitituion. *Nucleophilic aromatic substitution:* Mechanism and evidences in favour of it; S_NAr mechanism; Meisenheimer complex; cine substitution through benzyne intermediate. **Module II: Carbonyl compounds-II 12L** *Exploitation of acidity of α-H of C=O:* formation of enols and enolates; kinetic and thermodynamic enolates; reactions (mechanism with evidence): halogenation of carbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (H. V. Z.) reaction, nitrosation, SeO_2 (Riley) oxidation; condensations (mechanism with evidence): Aldol, Tollens', Knoevenagel, Claisen-Schmidt, Claisen ester including Dieckmann, Stobbe; Mannich reaction, Perkin reaction, Favorskii rearrangement; alkylation of active methylene compounds; preparation and synthetic applications of diethyl malonate and ethyl acetoacetate; specific enol equivalents (lithium enolates, enamines, aza- enolates and silyl enol ethers) in connection with alkylation, acylation and aldol type reaction.

	Nucleophilic addition to α,β-unsaturated carbonyl system: general principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction), Stetter reaction, Robinson annulation. *Substitution at sp^2 carbon (C=O system):* mechanism (with evidence): $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (in connection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison). **Module III: Organometallic compounds and Carbocycles 12L** *Grignard reagent; Organolithiums; Gilman cuprates:* preparation and reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; substitution on -COX; directed ortho metalation of arenes using organolithiums, conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behavior of Grignard reagents; comparison of reactivity among Grignard, organolithiums, Organocadmium and organocopper reagents; Reformatsky reaction; Blaise reaction; base-nucleophile dichotomy in case of organometallic reagents. *Polynuclear hydrocarbons and their derivatives:* synthetic methods include Haworth, Bardhan-Sengupta, Bogert-Cook and other useful syntheses (with mechanistic details); fixation of double bonds and Fries rule; reactions (with mechanism) of naphthalene, anthracene, phenanthrene and their derivatives. **Practical** Single-step organic synthesis *Organic preparations and detection of final compounds by melting point and TLC by locating solvent front and calculating Rf values* 1. Nitration of aromatic compounds 2. Condensation reactions Synthesis of dibenzylidene acetone from benzaldehyde and acetone 3. Hydrolysis of amides/imides/esters 4. Benzoylation of phenols/aromatic amines

	5. Side chain oxidation of aromatic compounds: Synthesis of p-nitrobenzoic acid from p-nitrotoluene by potassium dichromate in concentrated sulphuric acid. 6. Bromination of aniline using green approach (Bromate-Bromide method) 7. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline
Course Overview	Theory: To have knowledge about- i) Substitution reactions in aromatic compounds ii) Reaction and synthesis of Carbonyl and Related Compounds iii) Brief idea about organometallic compounds and carbocycles Practical: Single-step organic synthesis
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: Explain the mechanistic pathways and experimental evidence governing electrophilic and nucleophilic aromatic substitution processes, including the formation of Meisenheimer complexes. CO2: Predict the orientation, reactivity, and regiochemical outcomes (including ipso and cine substitutions via benzyne intermediates) of functionalized aromatic systems undergoing classical and named substitution reactions. CO3: Differentiate between kinetic and thermodynamic enolates, and apply specific enol equivalents (lithium enolates, enamines, silyl enol ethers) in selective alkylation, acylation, and condensation reactions. CO4: Design multi-step synthetic strategies leveraging advanced carbon-carbon bond-forming carbon condensations (e.g., Aldol, Claisen, Dieckmann, Stobbe, Perkin, Michael addition, Robinson annulation). CO5: Analyze the reaction mechanisms, kinetics, and structural effects influencing nucleophilic substitution at for carboxylic acids and their derivatives. Structural aspect and reactivity of hydrolysis of esters involving various mechanisms. CO6: Compare the reactivity, selectivity, and base-nucleophile dichotomy of diverse organometallic reagents (Grignard, Organolithiums, Gilman cuprates, Organocadmium) in addition and substitution pathways. CO7: Apply organometallic methodologies, including directed ortho-metalation (DoM) and Corey-House synthesis, to selectively functionalize complex organic frameworks. CO8: Formulate synthetic pathways for polynuclear aromatic hydrocarbons (naphthalene, anthracene, phenanthrene) using classical approaches (Haworth, Bardhan-Sengupta, Bogert-Cook) and predict their chemical reactivity using Fries' rule. CO9: Evaluate chemical hazards, assess regiochemical selectivity in structural puzzles, and safely execute synthetically rigorous carbon-carbon bond transformations 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: Aromatic Substitution	**CO1:** Explain the mechanistic pathways and experimental evidence governing electrophilic and nucleophilic aromatic substitution processes, including the formation of Meisenheimer complexes.	**K2** (Understanding) **K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO2: Predict the orientation, reactivity, and regiochemical outcomes (including *ipso* and *cine* substitutions via benzyne	**K3** (Applying) **K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving

	intermediates) of functionalized aromatic systems undergoing classical and named substitution reactions.		
Module II: Carbonyl Compounds-II	**CO3:** Differentiate between kinetic and thermodynamic enolates, and apply specific enol equivalents (lithium enolates, enamines, silyl enol ethers) in selective alkylation, acylation, and condensation reactions.	**K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO4: Design multi-step synthetic strategies leveraging advanced carbon-carbon bond-forming carbon condensations (e.g., Aldol, Claisen, Dieckmann, Stobbe, Perkin, Michael addition, Robinson annulation).	**K4** (Analyzing) **K6** (Creating)	**PO3:** Problem Solving **PO4:** Research Competency
	CO5: Analyze the reaction mechanisms, kinetics, and structural effects influencing nucleophilic substitution at for carboxylic acids and their derivatives. Structural aspect and reactivity of hydrolysis of esters involving various mechanisms.	**K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving

Module III: Organometallics & Carbocycles	**CO6:** Compare the reactivity, selectivity, and base-nucleophile dichotomy of diverse organometallic reagents (Grignard, Organolithiums, Gilman cuprates, Organocadmium) in addition and substitution pathways.	**K2** (Understanding) **K4** (Analyzing)	**PO1:** Core Knowledge **PO3:** Problem Solving
	CO7: Apply organometallic methodologies, including directed ortho-metalation (DoM) and Corey-House synthesis, to selectively functionalize complex organic frameworks.	**K3** (Applying)	**PO1:** Core Knowledge **PO5:** Modern Tool Usage
	CO8: Formulate synthetic pathways for polynuclear aromatic hydrocarbons (naphthalene, anthracene, phenanthrene) using classical approaches (Haworth, Bardhan-Sengupta, Bogert-Cook) and predict their chemical reactivity using Fries' rule.	**K3** (Applying) **K6** (Creating)	**PO1:** Core Knowledge **PO3:** Problem Solving
Cross-Cutting / Lab Links	**CO9:** Evaluate chemical hazards, assess regiochemical selectivity in structural puzzles, and safely execute synthetically rigorous carbon-carbon bond transformations within the laboratory.	**K3** (Applying) **K5** (Evaluating)	**PO2:** Laboratory Skills **PO6:** Communication Skills

Reading/Reference Lists	Theory: . Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012. . Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003. . Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited. . Carey, F. A. & Sundberg, R. J. ADVANCED ORGANIC CHEMISTRY: PART A STRUCTURE AND MECHANICSMS, Fifth edition, Springer, 2008. . Carey, F. A. & Sundberg, R. J. ADVANCED ORGANIC CHEMISTRY: PART B REACTIONS AND SYNTHESIS, Fifth edition, Springer, 2008. . Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008. . Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited. . Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). . Finar, I. L. Organic Chemistry (Volume 1) Pearson Education. 0. Maskill, H., Mechanisms of Organic Reactions, Oxford Chemistry Primer, Oxford University Press. 1. Norman, R. O. C. & Coxon, J. M. Principles of Organic Synthesis, Nelson Thornes Ltd, 1993. Practical 2. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors. 3. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003. 4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009). 5. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012). 6. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). 7. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.	
Evaluation	Theory: 60 Internal: 15 (CIA: 10; Other form of Assessment: 2; Attendance: 3) Semester Exam: 45	Practical: 40 CA: 38; Attendance:2
Paper Structure for Theory Semester Exam	Answer THREE out of FOUR questions, of 15 marks each.	