M.SC.,
ORGANIC CHEMSITRY

MODEL SYLLABUS

AUGUST- 2022

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,
CHENNAI – 600 005

DEPARTMENT OF ORGANIC CHEMISTRY	
Programme	**M. Sc Organic Chemistry**
Programme Code	**CHE**
Duration	**2 Years**

Program Outcomes (POs)	
Upon completion of M. Sc Organic Chemistry program, the students are expected to have:	
PO 1	Ability to identify and address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.
PO 2	Apply the knowledge of Organic Chemistry to design and execute any type of complex organic synthesis.
PO 3	Analyze and interpret spectroscopy tools to understand the structure and dynamics of Organic compounds.
PO 4	Qualify National level exams such as NET, GATE and other competitive examinations.
PO 5	Independent bench chemist to design and execute any type of Organic Synthesis.
PO 6	Enhanced capacity to think critically; ability to design and execute experiments independently and/or team under multidisciplinary settings.
PO 7	Provide theoretical background and develop practical skills for analyzing materials using modern spectroscopic methods and instruments.
PO 8	Apply appropriate techniques, resources, and modern ICT tools for understanding chemical resources.
PO 9	Apply the knowledge of organic chemistry to explore their applications in energy, environment, materials, medicines and technology for betterment of the society.
PO 10	Understanding of eco-friendly organic chemical processes and the impact of organic chemistry on health and environment.

Program Specific Outcomes (PSOs)	
Upon completion of M. Sc Organic Chemistry program, the students are expected:	
PSO 1	To independently carry out research in Organic Chemistry domain and prepare suitable technical report.
PSO 2	Apply the knowledge of Organic Chemistry in the domain of advanced research, education and perspective entrepreneurship.

PSO 3	Be an independent bench chemist to design and execute any type of Organic Synthesis.
PSO 4	Apply the advanced concepts of organic chemistry to solve complex problems involved in the design and execution of pharmaceutically important API molecules.
PSO 5	Design, analysis, synthesis and interpretation data to provide solutions to different industrial problems by working in the multi-disciplinary areas of chemical sciences.
PSO 6	To be familiar in handling basic and modern laboratory equipment's to carry out experiments and develop skills to interpret and explain the validity of experimental data in terms of accuracy and underlying theory.
PSO 7	To analyze and interpret the UV-Vis, IR, NMR and HRMS spectral data of Organic compounds to understand the functional groups and their structural framework.
PSO 8	To understand importance of organic compounds as natural products, hormones or enzymes and their biological significance.

List of Courses:

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
I	CHE C001	Fundamentals of Analytical Chemistry	CORE	3
I	CHE C101	Coordination and Nuclear Chemistry	CORE	3
I	CHE C201	Stereochemistry and Organic Reaction Mechanism	CORE	3
I	CHE C301	Thermodynamics, Electrochemistry and Chemical Kinetics	CORE	3
I	CHE C202	Organic Chemistry Practical-I	CORE	3
I	CHE C302	Physical Chemistry Practical-I	CORE	3
I	UOM S147	Software packages for Chemists	SOFT SKILL	2
I	UOM S115	Lab Safety and First Aid	SOFT SKILL	2
I		Elective (One subject from the following)	ELECTIVE	3
I	CHE E001	Electronics and Computers for Chemists	ELECTIVE	
I	CHE E101	Inorganic Reaction Mechanism	ELECTIVE	
I	CHE E201	Name Reactions in Organic Chemistry	ELECTIVE	
I	CHE E301	Essentials of Statistical Thermodynamics	ELECTIVE	
II	CHE C002	Analytical Instrumentation	CORE	3
II	CHE C102	Main Group Elements and Inorganic Polymers	CORE	3
II	CHE C203	Organic Reaction Mechanism	CORE	3
II	CHE C303	Quantum Chemistry and Group Theory	CORE	3
II	CHE C003	Analytical Chemistry Practical-I	CORE	3
II	CHE C103	Inorganic Chemistry Practical-I	CORE	3

II	UOM S117	Chemistry Databases	SOFT SKILL	2
II	UOM S118	Spectroscopy Instrumentation	SOFT SKILL	2
		Elective (One subject from the following)	ELECTIVE	3
II	CHE E002	Analysis of Complex materials	ELECTIVE	
II	CHE E102	Nuclear Chemistry	ELECTIVE	
II	CHE E202	Functional Group Transformation	ELECTIVE	
II	CHE E302	Macromolecular Chemistry	ELECTIVE	
III	CHE C601	Physical Methods in Chemistry	CORE	4
III	CHE C204	Organic Chemistry Practical-II	CORE	3
III	CHE C205	Organic Chemistry Practical-III	CORE	3
III	CHE E601	Biological Chemistry	ELECTIVE	3
III	CHE E604	Chemistry of Heterocycles, Organolithium and Asymmetric Synthesis	ELECTIVE	3
		Elective from Other School	ELECTIVE	3
III	PHY E008	Fundamentals of Molecular Spectroscopy (from other School)	ELECTIVE	
III	UOM I001	Short time exposure to Research Institution/Industrial training (Summer)	Internship	2
IV	CHE C206	Orbital Symmetry, Photochemistry and Non-conventional techniques in Organic Synthesis	CORE	4
IV	CHE C207	Chemistry of Natural Products	CORE	4
IV	CHE E204	Modern Synthetic Methodology and Spectrometric Identification of Organic Compounds	ELECTIVE	3
IV	CHE E603	Novel Reagents in Organic Synthesis	ELECTIVE	3
IV	CHE C208	Project/Dissertation	CORE	6
		TOTAL CREDITS		91

SEMESTER I

Course	**Core (I)**
Course Code	**CHE C201**
Title of the Course	**STEREOCHEMISTRY AND ORGANIC REACTION MECHANISM**
Credits	**3**
Pre-requisites, if any	Students should know about the fundamental aspects on stereochemistry, electrophilic and nucleophilic substitution reactions.
Course Objectives	• Realize the significance and relevance of stereochemistry • Role of electrophilic as well as nucleophilic substitution reaction in organic synthesis • Realize the concept of selectivity in organic transformations • Understand the concept of reaction mechanism • To visualize the concept of substitution Vs reactivity
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Learn about different aspects involved in stereochemistry and the relevance of the topic in all branches including biology (K1-K5)
CO 2	Understand the basic concept and origin of asymmetric synthesis (K2-K4)
CO 3	Learn about the significance of reaction intermediates and the rate of the reaction (K3-K5)
CO 4	Selectivity and synthetic utility of substitution reactions (K2-K6)
CO 5	Understand the relevance of conformation and reactivity in organic synthesis (K5 & K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**STEREOCHEMISTRY** Chirality, Symmetry elements, Asymmetric and Dissymmetric chiral molecules. Calculation of number of optical isomers. Stereochemistry of mono and di-substituted cyclopropane, cyclobutane, cyclopentane and cyclohexane. Stereochemistry of tri-substituted cyclopentane, tri-substituted pentane and tetra-substituted hexane. Description of various types of optically active compounds including allenes, cumulenes, spiranes, biphenyls, *trans*-cyclooctene, Ansa compounds cyclophanes and helicenes. Compounds containing two asymmetric centers-Erythro and threo isomers. Conversion of Fischer projection into perspective forms. Erythro and Threo-Inter conversion of Fischer to Sawhorse and Newman projections. Zig-Zag representation of glucose. Interpretation of homotopic, enantiotopic and diastereotopic atoms and faces. Origin of *Re*- and *Si*-faces. Prochiral

	chiral carbon. R & S nomenclature of simple compounds, allenes, spiranes, biphenyls, Ansa compounds and cyclophane systems. Optical rotation and enantiomeric excess (ee). Stereospecific and Stereoselective reactions. Asymmetric Synthesis-Crams rule and Felkin Anh Model. Conformational analysis of cyclohexane and di-substituted cyclohexanes.
II	**ALIPHATIC NUCLEOPHILIC SUSBTITUTION** Mechanism of nucleophlic substitution reaction: SN^1, SN^2 and SN^i mechanisms. Solvent and leaving group effects and neighboring group participation (NGP). Substitution at carbonyl, vinylic and bridgehead system. Substitution with ambident nucleophiles: "O" Vs "C" alkylation. Role of LDA, crown ethers and phase transfer catalysts (PTC) in nucleophilic substitution reactions. Generation of enolates, enolate selectivity (Kinetic Vs Thermodynamic), alkylation of enolates and stereochemistry of enolate alkylation. Mechanism of ester hydrolysis (only BAC^2, AAC^2 and AAL^1). Alkylation of active methylene compounds. Asymmetric alkylation (Evans, Enders and Meyers procedures). Preparation and synthetic utility of enamines, Finkelstein reaction and Wurtz coupling.
III	**AROMATIC ELECTROPHILIC & NUCLEOPHILIC SUSBTITUTION REACTIONS** Aromatic electrophilic substitution: mechanism of nitration, sulfonation, Friedel-Crafts alkylation and acylation reactions. Synthesis of di- and tri-substituted benzenes from benzene or mono-substituted benzenes. Haworth reaction (for naphthalene), Scholl reaction, Vilsmeier-Haack formylation, Gattermann reaction, Reimer-Tiemann and Bischler-Napieralski reactions. Aromatic nucleophilic substitution in aryl halides by Meisenheimer complex mechanism and benzyne mechanism. Various methods of benzyne generation and reactions of benzynes (inter and intramolecular). Reactions of aryldiazonium salts. Zeigler alkylation, Vicarious Nucleophilic Substitution (VNS), Chichibabin and Schiemann reactions. Hammett and Hammett-Taft equation-Significance of reaction constant (ρ) and substituent constant (σ). Methods of determining reaction mechanism.
Reading List (Print and Online)	• Organic Chemistry Portal: https://www.organic chemistry.org/ reactions.htm • Organic Synthesis Portal: http://www.orgsyn.org/ • Organic Chemistry notes: https://chemistrynotes.com/pages/organic-chemistry-notes • https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf • YouTube http://Leah4sci.com/chirality; • YouTube: https://www.youtube.com/watch?v=yZ8JDDnyxC4

Recommended Text/Reference Books	• Carey, F. A & Giuliano, R. M. (2012); Organic Chemistry 8th Edition, McGraw Hill (I) Pvt Ltd • Bruice, P. Y. (2014); Organic Chemistry, 7th Edition, Dorling Kindersley (I) Pvt Ltd • Wade, Jr, L. G. & Singh, M. S. (2008); Organic Chemistry 6th Edition, Dorling Kindersley (I) Pvt Ltd • Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Edition, Pearson • Smith, M. B & March, J. (2006); March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, John Wiley & Sons, Inc. • Kalsi, P. S & Oza, R. S. (2018); Organic Reactions: Stereochemistry and Mechanism, New Age International • Clayden, J, Greeves, N. Warren, S. (2017); Organic Chemistry, 2nd Edition, Oxford University Press. • Graham Solomons, T. W, Fryhle, C. B. (2014); Organic Chemistry, 10th Edition, Wiley.

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	M	S	S	M	M	M	L	M
CO2	M	M	M	S	S	M	M	M	L	L
CO3	L	L	M	S	S	M	S	L	L	M
CO4	L	M	L	S	M	M	L	M	L	L
CO5	L	L	M	S	M	M	M	L	L	L

***S-Strong M-Medium L-Low**

Course	**Core (II)**
Course Code	**CHE C202**
Title of the Course	**ORGANIC CHEMISTRY PRACTICAL-I**
Credits	**3**
Pre-requisites, if any	Students should know the basic techniques used in the organic laboratory for preparation, purification and identification of organic compounds.
Course Objectives	• To understand the basic techniques used in organic laboratory for preparation and purification of organic compounds • To compare theory with experiment by performing preparation of organic compounds • To understand the reaction mechanism and intermediates involved in organic reaction. • Able to visualize the organic transformations in the reaction flask.
Course Outcomes	On the successful completion of the course, students will acquire knowledge of:
CO 1	Good laboratory practices in handling laboratory glasswares and chemicals (K1-K6)
CO 2	To gain experience in the maintenance laboratory notebook (K2-K4)
CO 3	Well versed with common laboratory techniques such as reflux, recrystallization, vacuum filtration, aqueous extraction and melting point determination (K2-K5)
CO 4	To understand the difficulties involved in the preparation of organic compounds (K1-K5)
CO 5	Understand the differences in theory and practical concept (K4-K6)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**Single Stage Preparations** 1. Preparation of *p*-benzoquinone 2. Preparation of 2,5-ditertiarybutylhydroquinone 3. Preparation of 4,6-dimethylcoumarin 4. Preparation of dibenzyllideneacetone

	5. Preparation of 2,4-dinitrotoluene 6. Preparation of benzhydrol
II	**Double Stage Preparations** 1. Preparation of *p*-bromoaniline from acetanilide 2. Preparation of *p*-nitroaniline from acetanilide 3. Preparation of *m*-nitrobenzoic acid from methylbenzoate 4. Preparation of symmetric tribromobenzene and 2,4,6-tribromo iodobenzene from aniline
Reading List (Print and Online)	• https://www.youtube.com/watch?v=1oO-fQvMrkE • https://www.youtube.com/watch?v=oROSQnzSdZE
Recommended Text/Reference Books	• Vogel, A.I.; Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J.; Smith, P.W.G. (2003); Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Pearson Education

Method of Evaluation:

Internal (Continuous Assessment)	End Semester Examination	Total	Grade
60	40	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	M	M	M	M	M	M	M	S
CO2	M	L	M	M	M	M	M	M	L	L
CO3	M	M	M	L	S	M	L	L	M	M
CO4	L	M	L	M	M	L	M	M	L	L
CO5	M	M	M	M	M	L	M	L	L	L

***S-Strong M-Medium L-Low**

Course	**Elective (I)**
Course Code	**CHE E201**
Title of the Course	**NAME REACTIONS IN ORGANIC CHEMISTRY**
Credits	**3**
Pre-requisites, if any	Students must have known about the basic organic name reactions.
Course Objectives	• To understand new carbon-carbon formation by name reactions • To understand the heterocycle synthesis through name reactions • To study the significances of name reaction in organic synthesis • Importance of substitution reaction and their synthetic utilities
Course Outcomes	On the successful completion of the course, students will acquire knowledge of:
CO 1	Design and syntheses of organic molecules based on name reaction (K2- K5)
CO 2	Understand the mechanism involved in organic name reactions (K1-K4)
CO 3	Understand key intermediates involved in organic name reactions (K1- K4)
CO 4	Understand functional group transformations and reactivity in organic name reactions (K2-K4)
CO 5	Explore synthetic utility of name reactions in organic synthesis (K3-K5)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	Carbon-Carbon bond formation reactions-Perkin, Knovenagel, Wittig, Wittig-Horner, Vilsmeier Haack, McMurray, Glacer, Mannich, Pschorr, Simmons-Smith and Thorpe reactions.
II	Heterocycle forming reactions-Paal-Knorr synthesis of pyrroles; Hantsch synthesis of pyridines, Madelung, Reissert and Bischler synthesis of indole**;** Skraup, Friedländer , Doebner-Miller and Konard-Limpatch synthesis of quinoline. Pomerantz-Fritsch synthesis of isoquinoline.
III	Name reactions on substitution and substituents-Chichibabin reaction, Eschweiler Clark reaction, Polonowski reaction, Reissert reaction, Sommlett reactions, Mitsunobu reaction, Leukart reaction, Bucherer reaction, Willegerodt reaction and Willegerodt-Kindler reaction.
Reading List (Print and Online)	• https://nptel.ac.in/courses/104/103/104103110/ • https://nptel.ac.in/courses/104/105/104105034/ • https://nptel.ac.in/courses/104/101/104101115/

Recommended Text/Reference Books	• March, J. (2007); Advanced Organic Chemistry, 6th Edition, Wiley • Carey, F. Sundberg R. J. Advanced Organic Chemistry-Part A and B- 5th Edition, Springer • Clayden, J, Greeves, N, Warren, S. (2012); Organic Chemistry, 2nd Edition, Oxford

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	M	S	M	M	M	M	L	L
CO2	L	L	M	S	M	M	M	M	M	L
CO3	M	M	M	S	M	M	S	L	L	M
CO4	L	M	L	M	M	L	M	M	L	L
CO5	M	M	M	M	M	L	M	L	L	L

***S-Strong M-Medium L-Low**

SEMESTER **II**

Course	**Core (III)**
Course Code	**CHE C203**
Title of the Course	**ORGANIC REACTION MECHANISM**
Credits	**3**
Pre-requisites, if any	Students should know about the fundaments of concept of chemical reaction and their mechanism.
Course Objectives	• To study the basic concepts addition and elimination reactions and their mechanism. • To predict the selectivity and stereo-chemical outcome of addition reactions, elimination reactions, oxidation and reduction reactions • To understand the basic concepts of group or atom migration during molecular rearrangements along with mechanistic details • Realize importance of oxidation and reduction reagents in organic synthesis
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Understand different aspects of addition reactions and elimination reactions (K2-K5)
CO 2	Familiar with various types of molecular rearrangements and their mechanisms (K1-K6)
CO 3	Understand the concept of atom or group migration involved in molecular rearrangements (K2, K3, K4 and K5)
CO 4	Understand the significance and mechanism of various types oxidation and reduction reactions (K2, K4 and K5)
CO 5	Understand the selectivity and synthetic utility of addition, elimination, oxidation and reduction reactions (K1-K5)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**ADDITION AND ELIMINATION REACTIONS** Electrophilic addition to carbon–carbon double and triple bonds. Nucleophilic addition to carbon–carbon multiple bonds. Generation and addition of carbenes-Michael addition and Robinson annulation. Nucleophilic addition to –C=O bond- A study of Mannich, benzoin, Darzen's glycidic ester, Stobbe and Knovenegal condensation reactions-Wittig, Wittig-Horner olefination reaction- Julia & Peterson alkene synthesis.

	Elimination reactions: E_1, E_2, E_{1cb} and E_i-elimination. Conformation of mechanism; solvent, substrate, leaving group effects-Saytzeff's *Vs* Hoffman elimination; Chugaev and Cope elimination.
II	**MOLECULAR REARRANGEMENTS AND NAME REACTIONS** A study of mechanism of the following rearrangements: Beckmann, Curtius, Hoffmann, Schmidt, Lossen, Wolff, Pinacol, Wagner Meerwin, Demyanov, Dienone-Phenol, Favorski, Benzidine, Claisen, Cope, Sommlet-Hauser, Pummerer and Von-Richter rearrangements. A study of the following name reactions: Dieckmann cyclization, Hoffmann-Loffler Freytag reaction, Shapiro reaction, Eschenmoser-Tanabe and Ramburg-Backlund reactions.
III	**OXIDATION AND REDUCTION REACTIONS** Oxidation with Cr and Mn reagents; Oxidation with LTA, DDQ and SeO_2; Oxidation using DMSO either with DCC or Ac_2O or Oxalyl chloride; Oxidation using Dess Martin reagent. Hydroxylation of olefinic double bonds (OsO_4, $KMnO_4$); Woodward and Prevost oxidation. Epoxidation using peracids including Sharpless epoxidation, Ozonolysis. Reduction with $NaBH_4$, $LiAlH_4$, $Li(^tBuO)_3AlH$, DIBAL-H, Red-Al, Et_3SiH and Bu_3SnH; Reduction using selectrides, Birch reduction. Hydrogenation (homogenous and heterogeneous), hydration of carbon-carbon double and triple bonds. Asymmetric reduction of carbonyl functions (Corey's procedure).
Reading List (Print and Online)	• Organic Chemistry Portal: https://www.organic-chemistry.org/ • Organic Synthesis Portal: http://www.orgsyn.org/ • Organic Chemistry notes: https://nptel.ac.in/courses/104/101/104101005/ https://nptel.ac.in/courses/104/101/104101127/ • YouTube: https://onlinecourses.swayam2.ac.in/ugc19_ch01/preview • YouTube: https://onlinecourses.swayam2.ac.in/cec21_cy02/preview
Recommended Text/Reference Books	• Norman, R. O. C & Coxon, J. M (1993); Principles of Organic Synthesis, 3rd Edition, *CRC Press*. • Ahluwalia, V. K. (2012); Oxidation in Organic Synthesis, Ane Books Pvt. Ltd. • Smith, M. B. (2015); March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, John Wiley & Sons, Inc. • Carruthers, W. & Coldham, I. (2015); Modern Methods of Organic Synthesis, 4th Edition, Cambridge University press, UK. • Stuart Warren, (2007); Organic Synthesis: The Disconnection Approach, 2nd Edition, Wiley. • March, J (2006); Advanced Organic Chemistry, 4th Edition, Wiley. • Carey, F. A. & Sundberg, R. J. (2008); Advanced Organic Chemistry-Part A and B. 5th Edition, Springer.

	• Clayden, J, Greeves, N, Warren, S & Wothers, P (2000); Organic Chemistry, Oxford University Press. • House, H. O. (1998); Modern Organic Synthesis, 2nd Edition. W. A. Benjamin, New York.

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	S	L	S	S	M	L	M	L
CO2	M	M	M	L	S	S	M	M	L	L
CO3	M	M	M	M	S	M	M	L	L	L
CO4	M	M	M	M	S	S	M	M	L	L
CO5	M	M	S	M	S	M	L	M	L	L

***S-Strong M-Medium L-Low**

Course	**Elective (II)**
Course Code	**CHE E202**
Title of the Course	**FUNCTIONAL GROUP TRANSFORMATION IN ORGANIC CHEMISTRY**
Credits:	**3**
Pre-requisites, if any	Students should know about various types of functional groups as well as organic reactions
Course Objectives	• To learn various types of functional group transformations involving different types of oxidation reactions • To learn functional group transformations involving different types of reducing agents • To understand different types of functional group transformations involving miscellaneous category of reagents/name reactions • To identify suitable reagents for carrying specific synthetic transformations.
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Understand different types of functional group transformations involving oxidizing agents (K2-K5)
CO 2	Familiarize with functional group transformations involving reducing agents (K2-K6)
CO 3	Understand functional group transformations involving miscellaneous category of reagents/name reactions (K2-K5)
CO 4	Identify suitable reagents to perform chemo-selective functional group transformations (K1-K6)
CO 5	Evaluation of different types of synthetic transformations involving oxidizing, reducing and miscellaneous category of reagents (K1-K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**FUNCTIONAL GROUP TRANSFORMATIONS USING OXIDIZING REAGENTS** Use of Chromium reagents (CrO_3, $K_2Cr_2O_7$, CrO_2Cl_2, PCC, PDC and PFC). Use of Manganese reagents ($KMnO_4$, MnO_2, CTAP). Use of RuO_4, $KBrO_3$, DMSO, NCS, $NaIO_4$, peracids and boranes.
	FUNCTIONAL GROUP TRANSFORMATIONS USING REDUCING REAGENTS

	Use of $NaBH_4$, $NaCNBH_3$, $LiAlH_4$ and Bu_3SnH; Use of Sn/HCl, Zn/HCl, Hydrazine, Li-NH_3, Na/alcohol, Pd/H_2 and Raney Ni.
III	**FUNCTIONAL GROUP TRANSFORMATIONS USING MISCELLANEOUS TYPE OF REAGENTS** Use of $SOCl_2$, PBr_3, PPh_3-CCl_4, LiBr, NaI, NBS, PPh_3-X_2, Lawesson's reagent, Mitsunobu reagent, CH_2N_2, $TMSCHN_2$ and Barbier-Weiland degradation. Conversion of aldehyde to ketone and vice versa; Conversion of aldehyde to cyanide, Conversion of cyanide to ester, Conversion of ketone/aldehyde to phenol; conversion of ketone to enone.
Reading List (Print and Online)	• Organic Chemistry Portal: https://www.organic chemistry.org/ reactions.htm • Organic Synthesis Portal: http://www.orgsyn.org/ • Organic Chemistry notes: https://chemistrynotes.com/pages/organic-chemistry-notes • https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf • YouTube http://Leah4sci.com/chirality; • YouTube: https://www.youtube.com/watch?v=yZ8JDDnyxC4
Recommended Texts/Reference books	• Jerry March. (2006); Advanced Organic Chemistry, 4th Edition, Wiley. • Carey, F. A. & Sundberg, R. J. (2008); Advanced Organic Chemistry-Part A and B. 5th Edition, Springer. • Clayden, J, Greeves, N. Warren, S. (2017); Organic Chemistry, 2nd Ed, Oxford University Press. • Graham Solomons, T. W, Fryhle, C. B. (2014); Organic Chemistry, 10th Edition, Wiley. • Smith, M. B. (2015); March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, John Wiley & Sons, Inc.

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	L	S	S	S	M	M	L	M	M
CO2	M	M	S	S	S	L	L	M	L	M
CO3	M	M	S	M	S	M	L	L	M	S
CO4	M	M	M	M	S	S	L	M	L	S
CO5	M	M	S	M	S	M	L	L	L	M

***S-Strong M-Medium L-Low**

Course	**Soft skill**
Course Code	**UOMS-118**
Title of the Course	**SPECTROSCOPY INSTRUMENTATION**
Credits	**2**
Pre-requisites, if any	Basic knowledge on UV, IR, NMR and Mass Spectroscopy will be advantageous.
Course Objectives	The main objectives of this course are to: • To study the basic principles of molecular spectroscopy • To study the instrumentation aspects of molecular spectroscopy • To provide hands on training on various instruments such as UV, IR, NMR and Mass Spectroscopy Instrumentation.
Course Outcomes	On the successful completion of the course, students will acquire knowledge of:
CO 1	To carry out experiments individually and gain knowledge about principles and techniques involved in Spectroscopy (UV, IR, NMR and Mass) Instrumentations (K1-K3).
CO 2	Acquire skills in sampling techniques for spectral analysis (K2-K5)
CO 3	Acquire experimental skills and handling instruments (K2-K5)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**UV SPECTROSCOPY INSTRUMENTATION:** Principles – Instrumentation – hands on training-sample handling techniques – Application of UV-Visible spectroscopy. **IR SPECTROSCOPY INSTRUMENTATION:** Principles – Instrumentation – hands on training-sample handling techniques – Application of IR spectroscopy
II	**NMR INSTRUMENTATION:** Principles – Instrumentation – advantages of NMR techniques – Application of NMR
III	**MASS SPECTROMETRY:** Basic Principles – Instrumentation – advantages of mass techniques – Application of mass spectrometry

Reading List (Print and Online)	• https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf • https://www2.chemistry.msu.edu/courses/cem351/FS16_HUANG/Lecture_Presentation/Ch_10_Lecture_Presentation.pdf • https://www.slideshare.net/siraj174/sir-aj-nmr-spectroscopy-lecture • http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf • https://www.youtube.com/watch?v=qtpVfccYEHE&t=98s
Recommended Text/Reference Books	• Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Ed, Wiley • Kalsi, P. S (2016); Spectroscopy of Organic Compounds, 7th Ed, New Age International • Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4 • Jag Mohan (2016); Organic Spectroscopy Principles & Applications, 3rd Ed, Narosa Publishing House.

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	M	M	M	M	M	M	M	L
CO2	M	L	S	M	M	L	L	M	S	S
CO3	M	M	M	M	M	M	M	L	M	S

***S-Strong M-Medium L-Low**

SEMESTER III

Course	**Core (IV)**
Course Code	**CHE C601**
Title of the Course	**PHYSICAL METHODS IN CHEMISTRY**
Credits	**4**
Pre-requisites, if any	Students should know about the fundamental aspects on spectroscopy and their importance in the characterization of chemical compounds. Basic knowledge on UV-Vis, IR, NMR and Mass spectroscopic techniques will be advantageous.
Course Objectives	• To provide the deep understanding of electronic structural changes of metal coordination complexes upon interaction with visible light. • To understand basic theory and instrumentation involved in the origin of spectroscopy. • To understand UV, IR, NMR and Mass spectra and their significance in the characterization of organic compounds. • To illustrate the basic principle of splitting of spectral line of inorganic complexes in the presence of magnetic field upon interaction with electromagnetic radiation. • To understand role of spectroscopy (UV, IR, NMR & Mass spectroscopy) to determine the structure of organic compounds. • To learn ESR and their importance in the characterization of radicals. • To understand basic theory & instrumentation involved with analytical techniques for characterization and imaging
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Interpretation of various absorption band in the visible, IR and microwave region to understand the structural bonding, geometry and reactivity of inorganic coordination complexes (K1-K4)
CO 2	To understand the basic concept, interpretation and application of electronic spectra of hydrogen and many electron atoms also to derive angular momentum of many electron atoms and term symbols of atoms (K2-K4)
CO 3	Knowledge of crystal, vibrational, thermal, ATR and imaging modes to characterize chemical compounds (K3-K4)
CO 4	Understand basic theory as well as instrumentation techniques for recording UV, IR, NMR, ESR, MS, XRD, Raman, Mossbauer and Thermal spectra of chemical compounds (K2-K5)
CO 5	Interpretation of UV, IR, NMR, TGA, DSC, XRD, Raman, Mossbauer, ESR and MS spectra of compounds to understand their structural characteristics (K2-K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5-**Evaluate; **K6**-Create	
Units	

I	**ELECTRONIC SPECTROSCOPY (PHYSICAL & INORGANIC CHEMISTRY)** Spectra of hydrogen and many electron atoms, angular momentum of many electron atoms, term symbols, spectra of many electron atoms- Zeeman effect. Spectra of diatomic molecules, Representation of electronic states through potential energy diagrams-Frank Condon principle. Intensities of electronic transitions- theoretical treatment of absorption intensities, transition dipole moment integral, oscillator strength, selection rules parity, spin and symmetry considerations, Factors inducing forbidden transitions vibronic and spin orbit coupling, polarization bands. Spectra of formaldehyde, butadiene and benzene –group theoretical discussion. Electronic spectra of inorganic complexes – Selection rules (Laporte, orbital and spin selection rules), band intensities, band widths, spectra in solids, spectra of aqueous solutions of d^1-d^9 ions in O_h and T_d environments.
II	**MOSSBAUER & RAMAN SPECTROSCOPY, X-RAY AND THERMAL METHODS OF ANALYSES (ANALYTICAL CHEMISTRY)** Mossbauer spectroscopy: Introduction, principle, instrumentation, recoil energy, Doppler effect, number of MB signals, isomer shift, quadrupole splitting, magnetic hyperfine splitting applications to ^{57}Fe, ^{119}Sn and ^{129}I compounds Raman Spectroscopy: SERS, SERRS. ATR techniques – UV, IR, Raman. Principle & application of ORD and CD in the identification of complexes. 3D, 4D & 5D NMR imaging techniques X-ray diffraction – Bragg equation, space groups and point groups, diffraction methods. Thermal methods of analysis – TGA, DTA and DSC – Principle and applications.
III	**NUCLEAR MAGNETIC RESONANCE (ORGANIC CHEMISTRY)** Origin of NMR spectrum-Nuclear spin states – NMR active nuclei – Nuclear magnetic moment–Larmor equation – Absorption of energy and Resonance – Population density of nuclear spin states. Saturation phenomena – Relaxation mechanisms, Bloch equation (only significance and derivation not required). Comparison of CW and FT instrument–Chemical shift - Standards in NMR – Shielding and De-shielding – Factors affecting chemical shift – electronegativity, hybridization, hydrogen bonding - anisotropic effect – double, triple bond, aromatic compounds and carbonyl compounds. Spin-spin coupling – splitting origin and rules – factors affecting coupling constant: cis, trans, gem, ortho, meta, para coupling – exchange with deuterium. Vicinity of the proton, Long range coupling, Karplus equation and curve. ^{1}J, ^{2}J, ^{3}J, ^{4}J and ^{5}J coupling in NMR, order of NMR spectrum. Spin systems: Two interacting nuclei: A2, AB, AX, AA'BB', dd, pair of doublet, AB quartet. Three interacting nuclei: AMX, ABX, ABC systems (only

	pattern is required). Simplification of complex NMR spectra-Lanthanide shift reagents, CIDNP and NOE. Basic principles and applications of VT NMR & MRI. ^{13}C NMR – difficulties in recording ^{13}C NMR: Homo nuclear and heteronuclear coupling. Decoupling technique: SFORD and Off Resonance decoupled spectrum identification of various types of carbon using ^{13}C NMR. APT & DEPT spectra (DEPT-45, DEPT-90 and DEPT-135). ^{19}F NMR Precessional frequency and heteronuclear coupling. Identification of organofluoro compounds (CF3CO2Et and CF3CH2OH) using NMR. ^{31}P NMR – Chemicalshift and heteronuclear coupling. Identification of organophosphorus compounds suchas (CH3)3P, (C2H5O)2P=O and Ph3P. P-P bond in NMR. Basic principles of 2D NMR (COSY, NOSEY, HSQC & HMBC).
IV	**UV, IR, MS (ORGANIC CHEMSITRY) & ESR (INORGANIC CHEMSITRY)** Electronic absorption-Beer-Lamberts law, Types of electronic excitation. Chromophore and Auxochrome-Bathochromic and Hypsochromic shifts. UV-vis spectra of simple organic compounds such as alkenes, phenols, anilines, carbonyl compounds and 1,3-diketones. Woodward and Fieser rule for calculation of λ-max values of dienes and unsaturated ketones. Infrared Spectra: Identification of functional groups in Organic Compounds, Finger print region. Inter and Intramolecular hydrogen bonding Origin, basics and bloc diagram of Mass spectrum-Various types of Ionization techniques-Stability of Molecular ions, Meta stable ions. Base peaks and Isotope peaks. Fragmentation patterns of organic molecules such as benzenes, phenyl halides, phenols, benzyl alcohols, benzyl halides, aliphatic alcohols, aliphatic as well as aromatic aldehydes, ketones, acids, esters and amides. Fragmentation patterns of aliphatic/aromatic nitro and amine compounds. Fragmentation patterns of heterocyclic compounds (furan, pyrrole and pyridine only). McLafferty rearrangements of organic molecules. Structural determination of Organic Compounds using UV, IR, NMR and Mass Spectra. ESR Spectra of d^1-d^9 Transition Metal Complexes with examples. Interpretation of g in cubic, axial and rhombohedral geometries. Calculation of g values with simple examples. Intensities of '$g_{\parallel}$ and $g_{\perp}$ peaks. Evidence for Metal-Ligand Bond Covalency- Cu(II)- Bis –Salicylaldimine, Bis-Salilcylaldoximato copper(II) $[(NH_3)_5CoO_2CoNH_3)_5]^{5+,}$ Cu(II)-diethyldithiophosphinate, Vanadyldithiophsphinate, Copper(II) tetraphenylporphyrin, Co(II)- phthalocyanine, $K_2[IrCl_6]$. Interpretation of 'g' and 'A' values from esr spectral data in- i) MnF_6^{4-}, ii) CoF_6^{4-}, and CrF_6^{3-}.
Reading List (Print and Online)	• https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf • https://www2.chemistry.msu.edu/courses/cem351/FS16_HUANG/Lecture_Presentation/Ch_10_Lecture_Presentation.pdf

	• https://www.slideshare.net/siraj174/sir-aj-nmr-spectroscopy-lecture • http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf • https://www.youtube.com/watch?v=qtpVfccYEHE&t=98s • http://www.digimat.in/nptel/courses/video/104106122/L54.html • https://pubs.rsc.org/en/content/articlelanding/2018/cs/c6cs00565a • https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Magnetic_Resonance_Spectroscopies/Electron_Paramagnetic_Resonance/EPR%3A_Application
Recommended Text/Reference Books	• Chang, R (1971); Basic Principles of Spectroscopy, McGraw Hill, ISBN-13: 978-007010517 • Banwell, C. N.; McCash, E. M (1994); Fundamentals of Molecular Spectroscopy, IVth Edition, McGraw Hill, ISBN 0-07-707976-0 • Kemp, W. (2016); Organic Spectroscopy, 3rd Edition, Palgrave • Kalsi, P. S (2016); Spectroscopy of Organic Compounds, 7th Edition, New Age International • Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Edition, Wiley • Jag Mohan (2016); Organic Spectroscopy Principles & Applications, 3rd Edition, Narosa Publishing House • Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4 • Russell S. Drago, R. S (2016), Physical Methods for Chemists, II Edition, • Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K (2006); Inorganic Chemistry: Principles of Structure and Reactivity, IVth Edition, Pearson Education • Skoog, D. A; Holler, F.; Crouch, S (2017); Principles of Instrumental Analysis, 7th Edition, Brooks/Cole publisher • Ebsworth, E. A. V.; Rankin, D. W. H.; Craddock, S (1986); Structural Methods in Inorganic Chemistry, Wiley-Blackwell, ISBN-13: 978-0632015924 • Willard, H. H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F. A. Jr. (2004); Instrumental methods of analysis CBS Publishers & Distributors; 7th Edition, ISBN 13: 9780534081423 • Macomber, R. S (1998); A complete introduction to Modern NMR Spectroscopy, John Wiley, ISBN: 0-471-15736-8

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	M	M	M	M	L	M	L	L
CO2	M	M	L	M	L	L	M	M	L	L
CO3	L	L	L	M	L	M	M	L	M	L
CO4	M	M	M	S	M	M	M	L	L	L
CO5	M	M	S	S	L	M	M	L	L	L

*S-Strong; M-Medium; L-Low

Course	**Core (V)**
Course Code	**CHE C204**
Title of the Course	**ORGANIC CHEMISTRY PRACTICAL II** **DOUBLE STAGE ORGANIC PREPARATIONS**
Credits	**3**
Pre-requisites, if any	Basic knowledge on simple organic preparations will be essential
Course Objectives	The main objectives of this course are to: ● To provide practical training on double stage organic preparations ● Learn about the purification techniques of organic compounds by recrystallization and column chromatography ● To understand the mechanism and intermediates in organic reaction. ● To characterize the structure of the purified organic compound by IR and NMR.
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Gain practical skills on double stage preparations of organic compounds (K1-K6)
CO 2	Monitoring the progress of the reaction by TLC (K2-K5)
CO 3	Have experience on purification of organic compounds by recrystallization or column chromatography (K2-K4)
CO 4	Get adequate knowledge in synthetic organic chemistry (K3-K5)
CO 5	Characterization of prepared compounds by IR, ^{1}H NMR and Mass spectra (K2-K5)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**DOUBLE STAGE ORGANIC PREPARATIONS** 1. Synthesis of organic compounds involving Friedel-Crafts alkylation and acylation reactions 2. Synthesis of nitro compounds 3. Synthesis of halogenated compounds 4. Synthesis of aldehydes involving formylation reactions 5. Synthesis of organic compounds by using Pd-catalyzed coupling reactions 6. Synthesis of organic compounds involving nucleophilic substitution reactions

Reading List (Print and Online)	• Organic Chemistry notes: YouTube https://www.youtube.com/watch?v=N96JaRnE7n0 YouTube: https://www.youtube.com/watch?v=0RwDowIgXqk
Recommended Text/Reference Books	• Furniss, B. S.; Hannaford, A. J.; Smith, P.W.G.; & Tatchell, A.R. (2003); Vogel's Textbook of Practical Organic Chemistry, 5th Edition., Pearson Education • Mohan, J. (2010); Organic Analytical Chemistry, Theory and Practice, Narosa. • Mann, F. G & Saunders, B. C. (2009); Practical Organic Chemistry, fourth edition, Pearson Education India • Gnanaprakasam, N.S. & Ramamurthy, G. (2009); Organic Chemistry Lab Manual, Viswanathan, S., Printers & Publishers Pvt Ltd • Ahluwalia, V. K. Bhagat, P. & Aggarwal, R. (2013); Laboratory Techniques in Organic Chemistry, I K International Publishing House Pvt. Ltd

Method of Evaluation:

Internal	End Semester Examination	Total	Grade
30	20	50	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	L	M	M	M	M	M	M
CO2	M	L	L	M	M	M	M	M	M	M
CO3	S	L	M	L	M	M	M	M	S	S
CO4	M	M	M	M	M	L	L	S	L	L
CO5	L	M	S	M	L	M	M	L	L	L

***S-Strong M-Medium L-Low**

Course	**Core (VI)**
Course Code	**CHE C205**
Title of the Course	**ORGANIC CHEMISTRY PRACTICAL III** **MULTI-STAGE ORGANIC PREPARATIONS**
Credits	**3**
Pre-requisites, if any	Basic knowledge on simple organic preparations will be essential
Course Objectives	The main objectives of this course are to: ● To provide practical training on multi-stage organic preparations ● Learn about the purification techniques of organic compounds by recrystallization and column chromatography ● Learn about preparation of dry solvents to carry out moisture sensitive organic reactions ● To understand the mechanism and intermediates in organic reaction ● To characterize the structure of the purified organic compound by IR and NMR
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Gain practical skills in the preparations of organic compounds involving multi-steps (K1-K6)
CO 2	Monitoring the progress of the reaction by TLC (K2-K5)
CO 3	Have experience on preparation of dry solvents to carry out moisture sensitive organic reactions and purification of organic compounds by recrystallization or column chromatography (K2-K4)
CO 4	Get adequate knowledge in synthetic organic chemistry (K3-K5)
CO 5	Characterization of prepared compounds by IR, ^{1}H NMR and MS (K2-K5)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**MULTI-STAGE ORGANIC PREPARATIONS** 1. Synthesis of organic compounds involving condensation reactions 2. Synthesis of heterocycles 3. Synthesis of olefinic compounds using Wittig reactions 4. Synthesis of organic compounds involving oxidation/reductions 5. Synthesis of organic compounds involving protection/deprotection reactions 6. Synthesis of organic compounds involving Lewis acid/Bronsted acid mediated cyclization reactions

Reading List (Print and Online)	• Organic Chemistry notes: YouTube https://www.youtube.com/watch?v=N96JaRnE7n0 YouTube: https://www.youtube.com/watch?v=0RwDowIgXqk
Recommended Text/Reference Books	• Furniss, B. S.; Hannaford, A. J.; Smith, P.W.G. & Tatchell, A.R. (2003); Vogel's Textbook of Practical Organic Chemistry, 5th Edition., Pearson Education • Mohan, J. (2010); Organic Analytical Chemistry, Theory and Practice, Narosa. • Mann, F. G & Saunders, B. C. (2009); Practical Organic Chemistry, fourth edition, Pearson Education India • Gnanaprakasam, N. S. & Ramamurthy, G. (2009); Organic Chemistry Lab Manual, Viswanathan, S., Printers & Publishers Pvt Ltd • Ahluwalia, V. K.; Bhagat, P. & Aggarwal, R. (2013); Laboratory Techniques in Organic Chemistry, I K International Publishing House Pvt. Ltd

Method of Evaluation:

Internal	End Semester Examination	Total	Grade
30	20	50	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	L	M	M	M	M	M	M
CO2	M	L	L	M	M	M	M	M	M	M
CO3	S	L	M	L	M	M	M	M	S	S
CO4	M	M	M	M	M	L	L	S	L	L
CO5	L	M	S	M	L	M	M	L	L	L

***S-Strong M-Medium L-Low**

Course	**Elective (III)**
Course Code	**CHE E601**
Title of the Course	**BIOLOGICAL CHEMISTRY**
Credits	**3**
Pre-requisites, if any	Student able to understand the role of bio-organic compounds. Students should know about the fundamental aspects on biological system, mechanism, kinetics and analytical tools.
Course Objectives	• To understand the function of carbohydrate in biological chemistry, determination of ring size and study of starch and cellulose. • To understand the significances of amino acids, proteins nucleic acids in biological system. • Illustrate the importance of the various elements in the biological system and to gain more insights into the binding of metal complexes with biomacrmolecules and transport and storage mechanism involving in the metaloenzymes. • To understand the role of heavy metals in the human body- therapeutic and toxicity levels.
Course Outcomes	On the successful completion of the course, students will acquire knowledge:
CO 1	To learn about structural and functions of carbohydrates, lipids, membranes, amino acids, proteins, antibiotics and vitamins (K1-K5)
CO 2	Understand structure and biological importance of RNA and DNA (K2-K4)
CO 3	Understand the key function of metal ions such as Fe, Co, Ni Zn and Cu in living system, particularly in transports (energy and O_2), storage, electron- and proton transfer, hydrolysis, etc. which are taking place at the active site of metalloproteins and enzymes (K1-K4)
CO 4	Toxicity of metals and their effects in the biological system (K1-K4)
CO 5	To evaluate toxicity of drugs used in cancer and radiodiagnosis (K5 & K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
	BIO-ORGANIC CHEMISTRY

I	**Carbohydrates**: Pyranose and furanose forms of aldo-hexose and ketohexose-methods used for the determination of ring size-conformation of aldo-hexopyranose-structure and synthesis of lactose and sucrose. A brief study of starch and cellulose. **Lipids and Membranes**: Molecular structure of lipids. Fatty Acids, TriglyceridesTypes of membrane lipids **Amino acids and Proteins:** Amino acids and Protein structure, Analysis of N-terminal and C-terminals in a polypeptide. Sanger method, Edman degradation and Enzymatic analysis. Primary, secondary and tertiary structure of proteins. Structure of collagen, myoglobin and haemoglobin. **Nucleic acids: C**hemistry of nucleic acids, nucleosides and nucleotides – Structure RNA and DNA and their biological importance. **Biomolecules: Antibiotics and vitamins:** A detailed study of structure, and stereochemistry of penicillin, cephalosporin. Chemistry and physiological action of ascorbic acid, thiamin, riboflavin and pyridoxine – Elementary aspect of vitamin A, E, K and B12.
II	**BIO-INORGANIC CHEMISTRY** Essential and trace metal ions: Enzymes - Nomenclature and classification – Coenzymes - Vitamin B12, Carboxypeptidase and Superoxide dismutase – Heme-enzyme - Peroxidase and catalases. Oxygen carriers: Hemeproteins - Hemoglobin, myoglobin - Structure Oxygenation and stereochemistry - Bohr effect. Non-heme oxygen carriers - Hemerythrin and hemocyanin. Nitrogen fixation: Introduction, types of nitrogen fixing microorganisms. Nitrogenase enzyme - Metal clusters in nitrogenase - redox property - Dinitrogen complexes - transition metal complexes of dinitrogen - nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia. Biological redox systems: Cytochromes -Classification, cytochrome a, b and c. Cytochrome P- 450. Transport of electrons: Iron-Sulphur Proteins: Rubredoxins and Ferredoxins, Structural and Spectral features of Iron-Sulphur Proteins. Photosynthesis and chlorophyll's.
III	**BIO-PHYSICAL CHEMISTRY** Thermodynamics and biology-Basic concepts of structure and functionality-membranes-structure, function transport properties, aspects of electrochemical phenomena – active transport, ionophores, biological energy storage systems – stepwise mechanism of photosynthesis versus potential. Enzymes - Nomenclature and classification, chemical kinetics, the free energy of activation and the effects of catalysts, kinetics of enzyme catalyzed reactions – Michaelis - Menten equation - Effect of pH, temperature on enzyme reactions, Factors contributing to the catalytic efficiency of enzymes. Membranes - Phase Equilibria, Donnan effect, Donnan Potential, Phase transition in Lipid bilayers, Free energy determination for ATP hydrolysis from sodium-potassium pump, Allosteric effects – Monod-Wyman-

	Changeux Theory, Assigning of Statistical weights for Helix-Coil transition in proteins, Study by spectroscopic methods.
IV	**BIO-ANALYTICAL CHEMISTRY** Essentials of trace elements and chemical toxicology: Trace elements in biological system. Metal ion toxicity - classes of toxic metal compounds– detoxification. Metals in medicine: Anti-arthritis drugs – Au and Cu in rheumatoid arthritis – Li in psychiatry – Pt, Au and metallocenes in anti-cancer drugs- metals in radio diagnosis, radio therapy and magnetic resonance imaging. Transport and storage of metals: Mechanism – Fe, Cu, Zn and V storage and transport – metallothioeins. Molecular mechanism of iron transport across the membrane – sodium and potassium ion pumps. Pollution studies – Effluent and water treatment.
Reading List (Print and Online)	• https://www.youtube.com/watch?v=iuW3nk5EADg https://www.youtube.com/watch?v=aeC7M9PDjQw https://www.youtube.com/watch?v=DhwAp6yQHQI https://www.youtube.com/watch?v=ZqoX2W1N6l0 • https://www.youtube.com/watch?v=lsNalwRnaq0&list=PLbMVogVj5nJSHhL_cMKfzLv556ddrIT90 • https://www.youtube.com/watch?v=pXztk04J7u0&list=PLFW6lRTa1g83-gUOcT3ay875UG3a9Mu11
Recommended Text/Reference Books	• Zubay, G, L. (1997); Biochemistry, 4th Edition, Brown (William C.) Co • Nelson, D, L Lehninger, A, L Cox M, M. (2008); Principles of Biochemistry, 5th Edition, New York: W.H. Freeman. • John McMurray, (2008); Organic Chemistry, 8th Edition, Brooks/Cole. • Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Edition, Pearson • Williams D. R. (1976); Introduction to Bioinorganic Chemistry, Thomas, ISBN-13 : 978-0398034221. • Kaim, W, Schwederski, B, Klein, A. (2013); Bioinorganic chemistry: Inorganic Elements in the chemistry of life, 2nd Edition, Wiley. • Das Asim K. (2007); Bioinorganic Chemistry, 1st Edition, Books and Allied (P) Limited. • Mugherjee G. N, Arabinda D, (1993); Elements of Bioinorganic Chemistry, 4th Edition, U. N. Dhur & Sons Pvt. Ltd. • Satake M. Mido Y. (1996); Bioinorganic Chemistry, ISBN 81-7141-301-1, Discovery Publishing House, New Delhi. • Eichorn, G, (1973); Inorganic Bio-Chemistry Vol. I and II, IV Edition, Elsevier. • Zhimin, T, (2008); Analysis of Cytotoxicity of Anticancer Drugs, VDM Verlag Dr. Mueller E.K.ISBN: 9783639063486, 3639063481

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	L	M	M	M	M	M	L	M
CO2	L	M	L	S	L	M	L	M	M	M
CO3	L	L	M	S	L	L	M	L	L	M
CO4	L	L	L	M	L	M	L	M	L	L
CO5	M	L	M	M	L	L	M	L	L	S

***S-Strong M-Medium L-Low**

Course	**Elective (IV)**
Course Code	**CHE E604**
Title of the Course	**CHEMISTRY OF HETEROCYCLES, ORGANOLITHIUM AND ASMMETRIC SYNTHESIS**
Credits	**3**
Pre-requisites, if any	Students should know about the basic concept of five and six member heterocycles and asymmetric synthesis
Course Objectives	• Understanding different type of heterocycles and their stability • Reactivity pattern of different types of heterocyclic structures • Biological significance of heterocyclic frameworks • To correlate the selectivity and reactivity pattern of heterocycles • Various types of asymmetric synthesis and their synthetic utility • Importance of heterocyclic frameworks as drug intermediates
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Importance of heterocycles and their stability (K1 & K2)
CO 2	Understand the synthesis and reactivity of heterocycles (K1 & K2)
CO 3	Understand the significance and utility of heterocycles as drugs/drug intermediates (K3-K5)
CO 4	Understand the significance of naturally occurring heterocyclic frameworks (K4-K6)
CO 5	Understand and design the synthesis of chiral compounds (K3-K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5-**Evaluate; **K6**-Create	
Units	
I	**FIVE MEMBER HETEROCYCLES WITH ONE HETEROATOM** Furan, pyrrole and thiophene. Synthesis, reactions including lithiation, electrophilic substitution, Nucleophilic substitution, aromatic character, Comparative study of their reactivity.
II	**FIVE MEMBER HETEROCYCLES WITH TWO HETEROATOMS** Imidazole, oxazole, thiazole and their benzo analogues-Synthesis, reactivity including lithiation and aromatic character. Comparative study of their reactivity. Isoxazole, isothiazole and pyrazole-Synthesis and reactivity including lithiation. Indole, benzo[*b*]thiophene and benzo[*b*]furan-Synthesis and reactivity including lithiation.
III	**SIX MEMBER HETEROCYCLES WITH ONE HETEROATOM** Pyridine-Synthesis and reactivity; Pyridine-N-oxide-Synthesis and reactivity; quinoline and isoquinoline-synthesis and reactivity. Pyrimidines and Purines-Synthesis and reactivity (lithiation also included)

IV	**ASYMMETRIC SYNTHESIS** Selectivity, Resolution-Kinetic resolution reactions, Desymmetrization, Asymmetric Induction, Chiral auxiliary. Generation of Asymmetric synthesis-Substrate-Auxiliary-Reagent and Catalyst Control. Auxiliary controlled Alkylation of chiral enolates, Evans oxazolidones, chiral hydrozones and chiral imines. Enders RAMP/SAMP and chiral sulfoxide. Asymmetric Diels's Alder reaction, Simmon's-Smith reaction and Aldol reaction. Asymmetric oxidation [dihydroxylation, epoxidation Sharpless, Jacobsen, Shi] and Asymmetric reduction (Noyori, Corey, Pfaltz)-Boranes reduction.
Reading List (Print and Online)	• Organic Chemistry Portal: https://www.organic-chemistry.org/reactions.htm • Organic Synthesis Portal: http://www.orgsyn.org/ • Organic Chemistry notes: https://chemistrynotes.com/pages/organic-chemistry-notes • https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf • YouTube http://Leah4sci.com/chirality • YouTube: https://www.youtube.com/watch?v=yZ8JDDnyxC4
Recommended Text/Reference Books	• Bansal, R. K (2014); Heterocyclic Chemistry, 5th Edition, New Age International • Joule, J. A & Mills, K (2010); Heterocyclic Chemistry, 5th Edition, Wiley • Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Ed, Pearson • Clayden, J, Greeves, N. Warren, S. (2017); Organic Chemistry, 2nd Edition, Oxford University Press • Wade, L. G (2018); Organic Chemistry, 8th Edition, Pearson India • Graham Solomons, T. W, Fryhle, C. B. (2014); Organic Chemistry, 10th Edition, Wiley • Li, J. J (2010), Name Reactions in Heterocyclic Chemistry; Wiley (India), ISBN: 978-81-265-2387-0 • Gawley, R. E & Aubé, J (2012); Principles of Asymmetric Synthesis, 2nd Edition, Elsevier • Caprio, V, Williams, J. M. J (2009); Catalysis in Asymmetric Synthesis, 2nd Edition, Wiley • Kagan, H. B (1997); Asymmetric Synthesis: Fundamentals and Applications, ISBN-13: 978-313137101 • Noyori, R (1994); Asymmetric Catalysis in Organic Synthesis, ISBN: 978-0-471-57267-1

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	S	S	S	L	M	L	L
CO2	L	M	L	S	S	M	M	L	L	L
CO3	M	M	M	S	L	L	L	M	S	S
CO4	L	L	M	S	M	S	M	L	M	M
CO5	L	L	S	S	M	L	M	L	L	L

*S-Strong; M-Medium; L-Low

SEMESTER **IV**

Course	**Core (VII)**
Course Code	**CHE C206**
Title of the Course	**ORBITAL SYMMETRY, PHOTOCHEMISTRY, AROMATICITY AND NON-CONVENTIONAL TECHNIQUES IN ORGANIC SYNTHESIS**
Credits	**4**
Pre-requisites, if any	Basic knowledge on molecular orbitals, photochemistry and non-conventional techniques will be essential.
Course Objectives	The main objectives of this course are to: • Understand the concept of pericyclic reactions and analysis of the symmetry of the molecular orbitals to predict allowed and forbidden reactions. • Able to predict the con-rotatory and dis-rotatory electrocyclic ring-opening and ring-closure reactions along with stereochemical outcome of the reactions under thermal and photochemical conditions. • Understand the mechanisms of different types of pericyclic reaction: cycloadditions, electrocylic reactions, sigmatropic reactions and group transfer reactions. • Realize the concept of photochemistry and reactions along with synthetic utility of various Photochemical Reactions • To learn criteria for aromaticity and effect of structure on reactivity of the organic compounds • To understand basic principles (green chemistry/atom economy) and applications of non-conventional techniques and their comparison with conventional methods of organic synthesis
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Learn about different aspects of pericyclic reactions and skills for the utilization of these reactions in the organic synthesis (K1-K5)
CO 2	Able to predict the relevant *con*-rotatory and *dis*-rotatory rotation in electrocyclic ring-opening and ring-closure reactions (K2-K4)
CO 3	To understand reaction feasibility and selectivity by applying the Woodward–Hoffmann rules (K1-K6)
CO 4	Understand the concepts of photochemistry and to study the synthesis & applications of various types of photochemical reactions (K1-K5)

CO 5	Able to identify aromatic, non-aromatic and anti-aromatic systems; To understand basic principles, importance and applications of non-conventional techniques (K1-K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**BASIC CONCEPT OF MOLECULAR ORBITAL THEORY AND PERICYCLIC REACTION IN ORGANIC REACTIONS** Basic concept of conservation of orbital symmetry, electrocyclic and cycloaddition reactions, correlation diagram, FMO, PMO treatment. Ring closure reaction focusing system such as butadiene, pentadienylanion, pentadienyl cation, allyl anion, allyl cation, hexatriene, heptatrienyl cation, heptatrienyl anion, and octatetraene. Application of electrocyclic reactions in synthesis of terpenes, steroids and alkaloids. Stereoselectivity, regioselectivity, periselectivity and site selectivity in cycloaddition. 1,3-dipolar cycloaddition, click reaction, 2 + 2, 4 + 2, 4 + 4, 6 + 2, and 6 + 4 cycloaddition reactions. Secondary orbital interactions in cycloadditions. Normal and Inverse electron demand Diels-Alder reaction.
II	**PERICYCLIC REACTION IN ORGANIC REACTIONS** Sigmatropic and Cheleotropic reactions, correlation diagram, FMO & PMO treatment. Hydrogen migration. Carbon migration with symmetric and asymmetric centre. C-C bond migration, Orbital treatment for Cope, Claisen and 2,3-Sigmatropic reaction. Extrusion of CO_2, CO, SO_2 orbital symmetry treatment. Applications of Sigmatropic and Cheleotropic reactions in organic synthesis. Combination of cheleotropic reaction with cycloaddition.
III	**ORGANIC PHOTOCHEMISTRY** Organic photochemistry: Principles of photochemistry, Fate of excited state: Physical and Chemical process; [2 + 2] photochemical cycloaddition; Paterno-Büchi reaction; Photochemistry of cyclohexadienones, Norrish type I & II reactions. Oxidation and reduction reactions: Reaction with singlet oxygen. Selected reactions: Photo Fries, Barton, di-π methane, oxa & aza di-π methane rearrangements.
IV	**AROMATICITY AND NON-CONVENTIONAL TECHNIQUES** Aromaticity-Study of benzenoid and non-benzenoids compounds in the light of Huckel's rule. Aromaticity of annulenes. Basic principles of non-conventional techniques: Microwave, Sonication, Ball-milling techniques in organic reaction. Organic reactions in aqueous phase; Ionic liquids and their applications in organic synthesis. Tandem, cascade and domino reactions in organic synthesis. Concept of green chemistry. Atom economy.
Reading List (Print and Online)	• Organic Chemistry Portal: https://organicchemistrydata.org/hansreich/resources/pericyclic/?page=pericyclic00%2F

	• Organic Synthesis Portal: http://www.stereoelectronics.org/webPR/PR_home.html • Organic Chemistry Videos: https://nptel.ac.in/courses/104/106/104106077/ https://nptel.ac.in/courses/104/105/104105038/ https://courses.mookit.in/course/course009
Recommended Text/Reference Books	● Singh, J (2019); Photochemistry and Pericyclic Reactions, New Age International Publishers. ● Sankararaman, S (2005); Pericyclic Reactions- A Textbook: Reactions, Applications and Theory, Wiley-VCH. ● Halton, B & Coxon, J. M (2011); Organic Photochemistry, Cambridge University Press. ● Kumar, S. Kumar, V & Singh, S. P (2015); Pericyclic Reactions, I Edition, Academic Press. ● Norman, R.O.C & Coxon, J. M (1993); Principles of Organic Synthesis, II Edition, CRC Press. ● Finar, I. L. (2002); Organic Chemistry Vol 2: Stereochemistry and the Chemistry of Natural product, 5th Edition, Pearson Education India. ● Bruice, P. Y. (2014); Organic Chemistry, 7th Edition, Dorling Kindersley (I) Pvt Ltd ● Fleming, I (2009); Molecular Orbitals and Organic Chemical Reactions-Student Edition, Wiley. • Carey, F. A. & Sundberg, R. J. (2008); Advanced Organic Chemistry-Part A and B, V Edition, Springer. • Clayden, J, Greeves, N, Warren, S & Wothers, P (2000); Organic Chemistry, Oxford University Press. ● Warren, S (2008) Organic Synthesis, 2 Edition, Wiley. ● Corey, E. J & Cheng, X-M (1995); The Logics of Chemical Synthesis, I Edition, Wiley.

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	L	S	S	M	L	M	L	M
CO2	M	M	L	S	S	M	M	L	L	L
CO3	L	M	M	S	M	M	L	L	L	M
CO4	M	M	M	S	S	M	M	L	L	S
CO5	L	M	M	S	M	L	M	L	L	S

***S-Strong M-Medium L-Low**

Course	**Core (VIII)**
Course Code	**CHE C207**
Title of the Course	**CHEMISTRY OF NATURAL PRODUCTS**
Credits	**4**
Pre-requisites, if any	Students should know about the routine organic name reactions and basic synthetic transformations
Course Objectives	• Understanding different types of Total Synthesis and their importance • Realizing the importance of Natural Products and their Biological Significance • Acquiring knowledge to design any Targeted Synthesis • Analyzing Retrosynthetic pattern and designing Total Synthesis of natural products • Understanding the role of key reaction in designing skeletal framework of natural products • Understanding the biosynthetic pattern of natural products
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Design retro-synthetic pattern of any given target compound (K1-K3)
CO 2	Well versed with design and total synthesis of natural products (K2-K4)
CO 3	Understand the significance of the key reactions in assembling skeletal framework of natural products (K3-K5)
CO 4	Learn about the synthetic utility of organic reactions to achieve the total synthesis of natural products (K2-K6)
CO 5	Understand the biosynthetic pattern of any given natural products (K2- K6)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**ALKALOIDS** Total Synthesis of the following alkaloids: Preussin, Swainsonine, Horsifiline, Epibatidine, Camptothecin, Ellipticine, Ibogamine and Reserpine (Racemic as well as Chiral Syntheses wherever applicable)
II	**STEROIDS** Total Synthesis of Steroids: Androsterone, Testosterone, Estrone, Estradiol, 2-Methoxyestradiol and Progesterone (Racemic as well as Chiral Synthesis wherever applicable). Conversion of Cholesterol into the above mentioned steroids. Chiral as well as Racemic synthesis of Prostaglandins PGE1, PGE2 and PGE3

III	**TERPENES** Total Synthesis of Terpenes: Cedrene, Caryophyllene and Longifolene (Racemic as well as Chiral Synthesis wherever applicable). Menthol, Hirsutene, Capnellene, Silphiperfolene and 5-Oxosilphiperfolene (Racemic as well as Chiral Syntheses wherever applicable).
IV	**BIOSYNTHESIS** Biosynthesis of Alkaloids, Steroids, Terpenes and Prostaglandins.
Reading List (Print and Online)	• https://organicchemistrydata.org/hansreich/resources/syntheses/?page=abscisic-acid-constantino%2F • https://people.chem.umass.edu/mcdaniel/chem269/experiments/trimyristin/Natural-product-synthesis-an-art.pdf • https://authors.library.caltech.edu/25034/31/BPOCchapter30.pdf • https://w3pharm.u-shizuoka-ken.ac.jp/~yakuzo/pass-eng/pdf-eng.html
Recommended Text/Reference Books	• Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Edition, Pearson • Carey, F. A. & Sundberg, R. J. (2015); Advanced Organic Chemistry-Part A & B, Vth Edition, Springer, ISBN 978-81-322-0426-8 • Norman R. O. C & Coxon, J. (2017); Principles of Organic Synthesis, 3rd Edition, CRC Press • Wyatt, P & Warren, S. (2013); Organic Synthesis: Strategy and Control, Wiley • Corey, E. J & Cheng, X.-M (2011); The Logics of Chemical Synthesis, VCH, ISBN: 978-81-265-3034-2 • Nicolau, K. C & Sorenson, E. J (1996); Classics in Total Synthesis, VCH, ISBN: 978-3-527-29231-8

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	L	M	M	S
CO2	M	S	L	S	S	M	L	M	L	M
CO3	L	S	L	S	S	M	M	L	M	M
CO4	M	S	L	S	S	S	M	L	M	M
CO5	L	M	S	M	S	M	L	L	L	M

*S-Strong; M-Medium; L-Low

Course	**Elective (V)**
Course Code	**CHE E204**
Title of the Course	**MODERN SYNTHETIC METHODOLOGY AND SPECTROMETRIC IDENTIFICATION OF ORGANIC COMPOUNDS**
Credits	**3**
Pre-requisites, if any	Basic idea about the concept of retrosynthetic analysis and synthetic utility of common organic reactions are essential. Interpretation of UV, IR, NMR and Mass spectral of simple organic compounds will be an added advantage.
Course Objectives	• To understand the concept of retrosynthetic analysis which is heart of the organic synthesis • To study about various types of 1,3-dipolar cycloaddition and cyclization methodologies • To study the concept of domino and tandem reactions along with their synthetic utility. • The students are expected to learn organic spectroscopy techniques to determine the structure of complex organic compounds • To understand 2D-NMR techniques and interpretation for structurally complex Organic compounds.
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Understand the principles and application of tandem, cascade and domino reactions in organic synthesis (K2-K6)
CO 2	Apply of retrosynthetic analysis for synthesis of organic compounds (K2 and K3)
CO 3	Understand the synthetic utility and applications of various types of cyclization as well as 1,3-dipolar cycloaddition reactions (K2-K6)
CO 4	Student can able to solve the problems related to structure of organic compounds using spectral data (K1-K5) and apply organic spectroscopy knowledge to their research problems (K2-K4)
CO 5	To differentiate isomeric compounds using 2 D NMR Spectra of Organic Compounds COSY (HSQC, HMBC) and NOESY (K2-K5)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units	
I	**RETROSYNTHESIS, CYCLIZATION & TANDEM REACTIONS** Synthons (acceptor and donor)-Retrosynthetic analysis, Umpolung, Anti-thesis. Synthetic utility of 1,3-dithiane and TOSMIC. Various types of

	cyclization and ring formation reaction: anionic, cationic, radical and transition metal mediated cyclizations. Concept of Tandem, cascade and domino reactions in organic synthesis.
II	**CYCLOADDITION & ANNULATIONS REACTIONS** 1,3-Dipolar cycloaddition methodologies (Azide, nitrile oxide, azomethine ylides and carbonyl ylides). Annulation using phosphorous Ylides. Sulfur and Sulfonium ylides and their reactions, C=C bond forming reactions (Wittig, Wittig-Horner, Peterson and Julia olefination). Protective groups in Organic Synthesis
III	**ADVANCED SPECTRAL TECHNIQUES FOR STRUCTURAL CHARACTERIZATION OF ORGANIC COMPOUNDS** UV Spectra of organic molecules-Types of electronic transitions and Substituent and Solvent effects on λmax values of organic compounds. Application of Woodward-Fieser rules for calculation of λmax values of dienes as well as α,β-unsaturated ketones. IR spectroscopy–Position of IR absorption frequencies of organic compounds. NMR Spectroscopy-Interpretation of ^{1}H and ^{13}C NMR and DEPT spectral data of organic compounds. Illustration of 2 D NMR Spectra of Organic Compounds COSY (HOMO, HETERO), HSQC, HMBC. NOE and NOESY of Organic Compounds.
IV	**DETERMINATION OF STRUCTURE OF ORGANIC COMPOUNDS USING SPECTRAL DATA** Interpretation of mass spectral splitting pattern of organic compounds– Determination of structure of organic compounds using UV, IR, NMR and Mass spectral data.
Reading List (Print and Online)	• https://www.slideshare.net/guest824336/introduction-to-spectroscopy • https://nptel.ac.in/courses/104/105/104105087/ • https://www.youtube.com/watch?v=WKP0m1DuBag • https://www.youtube.com/watch?v=0_AxTP0HsuA • https://www.youtube.com/watch?v=umgfQyQCLSQ • https://www.slideshare.net/anthonycrasto64/2d-nmr-organic-spectroscopy-by-dr-anthony-crasto • https://www.youtube.com/watch?v=g_u1tR0cZHE • https://www.youtube.com/watch?v=ElNtU_BB1fs • https://www.vanderbilt.edu/AnS/Chemistry/Rizzo/Chem220b/Ch13.pdf
Recommended Text/Reference Books	• Carey, F. A. & Sundberg, R. J. (2015); Advanced Organic Chemistry-Part A & B, Vth Edition Springer, ISBN 978-81-322-0426-8 • Norman R. O. C & Coxon, J. (2017); Principles of Organic Synthesis, 3rd Edition, CRC Press • Wyatt, P & Warren, S. (2013); Organic Synthesis: Strategy and Control, Wiley • Kalsi, P. S (2017); Organic Synthesis through Disconnection Approach, ISBN-13: 978-938599846

	• Warren, S. & Wyat. P. (2008); Organic Synthesis: Disconnection Approach, II Edition, Wiley • Corey, E. J & Cheng, X.-M (2011); The Logics of Chemical Synthesis, VCH, ISBN: 978-81-265-3034-2 • Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Edition, Wiley • Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4 • Lambert, J. B, Shurvell, H. F, Lightner, D. A, Graham Cooks, R (1998); Organic Structural Spectroscopy, Prentice Hall, ISBN: 0-13-258690-8 • Macomber, R. S (1998); A complete introduction to Modern NMR Spectroscopy, John Wiley, ISBN: 0-471-15736-8

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	M	M	M	M
CO2	M	M	L	S	S	M	L	M	L	L
CO3	S	S	L	S	S	S	L	L	M	L
CO4	M	S	S	S	S	S	M	L	M	S
CO5	L	S	M	S	S	M	L	L	L	M

*S-Strong; M-Medium; L-Low

Course	**Elective (VI)**
Course Code	**CHE E603**
Title of the Course	**NOVEL REAGENTS IN ORGANIC SYNTHESIS**
Credits	**3**
Pre-requisites, if any	Students should learn about the basics of metal-catalyzed organic synthesis, including understanding mechanism, role of catalyst and other additives. In addition, students must be aware of the difference in the reaction mechanism involving typical organic reaction Vs carbon-metal catalyzed reaction.
Course Objectives	• To understand various types of metal-catalyzed organic syntheses, including Ring Closing Metathesis, synthesis of cyclic and acyclic molecules, new carbon-carbon & C-N bond formation and C-H activation. • To know utility of silicon compounds in the generation of reactive diene like ortho-quinodimethane and its application. • To understand the mechanism and synthetic application of trifluoromethylation using Ruppert-Prakash reagent • To study the correlation between structure, properties and reactivity of various types metal carbon bond compounds • Understanding the homogeneous and heterogeneous metal-carbon bond catalyzed reactions and their mechanism
Course Outcomes	On the successful completion of the course, the students will acquire knowledge of:
CO 1	Metal-catalyzed organic reactions and their synthetic utility (K1-K4)
CO 2	Study the various types of carbon-carbon formation reactions and synthesis of cyclic and acyclic frameworks (K2-K5)
CO 3	To study specific reaction by comparing theoretical and/or experimental data (K2-K4)
CO 4	To get new ideas or innovation in the field of organometallic chemistry and their applications in organic synthesis (K1-K6)
CO 5	To design suitable organometallic compounds for activation of highly stable and symmetrical molecules such as CO_2 and methane for the synthesis of industrially important intermediates/compounds (K3-K6)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	

Units	
I	Application of following d & p block elements in organic synthesis: Synthetic utility of Samarium iodide, Ruthenium (Ring Closing Metathesis-RCM) Zirconium (Schwartz's reagent) and Cobalt (Pauson-Khand reaction and Nicholas reaction) in organic synthesis. Asymmetric Reformatsky reaction using Samarium. Homogeneous hydrogenation. Application of Titanium in organic synthesis – Mc Murry coupling. Tin in organic synthesis. Use of – Bu_3SnH and Tin mediated carbon-carbon bond formation in the synthesis of cyclic and acyclic molecules.
II	Role of Palladium and Nickel catalyst in organic reactions. Both Pd(0), Ni(0) and Pd(II), Ni(II) complexes are included. Typical reaction involving Heck, Negishi, Suzuki-Miyaura, Kumada, Sonogashira, Stille and Hiyama coupling for the carbon-carbon bond formation. Buchwald-Hartwig coupling for the carbon-heteroatom bond formation reactions. Transition-metal catalyzed C-H bond activation in organic synthesis.
III	Silicon compounds. Use of trimethylsilyl chloride and t-butyldimethylsilyl chloride as a productive group. Use of trimethylsilyl iodide and trimethylsilyl cyanide. Vinylsilanes-Silyl Peterson olefination reaction. Trichloro silane and triethyl silane as reducing agents. Role of trimethylsilyl group in the generation of reactive diene like ortho-quinodimethane. Generation and reactions of α and β silyl-carbanions. Conjugate addition using lithium organo cuprates (Gilman's reagent) 1,2 vs 1,4 addition. Umpolung-aldehyde ketone and acid synthesis from 1,3 dithiane. Trifluoromethylation using Ruppert-Prakash reagent.
IV	Metal carbonyl reactions-substituted metal carbonyls, cis-labilising effect, metal-metal bonded carbonyl and cluster-insertion reaction-CO insertion, CO_2 insertion, SO_2 insertion, methyl migration, phenyl migration, carbon hydrogen bond activation-Oxo reaction, Wacker process and Reppe synthesis-photochemical reaction of metal carbonyls-Chromium, Manganese, Iron, Rhenium and Ruthenium. Oxidative addition-Hydrogen, organic halides-Fischer Tropsh process.
Reading List (Print and Online)	• https://www.youtube.com/watch?v=s8VqAqibrr8 • https://www.youtube.com/watch?v=YAkAKsHsLyU • https://www.youtube.com/watch?v=8pqCeN7GoMc&list=PLbMVogVj5nJR65WP0IQaDCBtCRq_HAuI_
Recommended Text/Reference Books	• Colvin, E. W. (1981); Silicon in Organic Synthesis, 1st Edition, Elsevier • Carruthers, W. (2015); Modern Methods of Organic Synthesis, 4th Edition, Cambridge University Press • Smith,M, (2016); Organic Synthesis, 4th Edition, Academic Press

	• Huhee, J. E, (2014); Inorganic Chemistry, 4th Edition, Pearson • Purcell K. F, Kotz, J. C. (1980); Inorganic Chemistry, 1st Edition, Thomson Learning • Weber, W. P. (1983); Silicon Reagents for Organic Synthesis, Springer-Verlag, ISBN 978-3-642-68661-0 • Tsuji, J. (2004); Palladium Reagents and Catalysts, Wiley, ISBN: 978-0-470-85032-9 • Hegedus, L. S. (2009); Transition Metals in the Synthesis of Complex Organic Molecules, 3rd Edition, University Science Books • Crabtree. R. H. (2019); The Organometallic Chemistry of the Transition Metals, Wiley

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create (K6) – Check knowledge in specific or off beat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	L	S	M	M	M	M	L	L
CO2	M	M	M	S	S	M	M	L	M	M
CO3	M	M	M	M	S	M	S	L	M	L
CO4	L	M	L	S	M	L	M	M	L	L
CO5	M	M	M	S	M	L	M	L	M	M

***S-Strong M-Medium L-Low**