Progressive Education Society's

Modern College of Arts, Science and Commerce (*Autonomous*),

Shivajinagar, Pune -05

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For

M.Sc. Part II (Organic Chemistry)

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2026-27)

P. E. Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune-05

M.Sc. II (Organic Chemistry)

Syllabus 2026-27

Semester 3

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScChOP311	Major Paper 1 (Theory)	Photochemistry, Free radicals and Pericyclic Reactions	4	4	50	50	100
	23ScChOP312	Major Paper 2 (Theory)	Heterocyclic Chemistry	4	4	50	50	100
	23ScChOP313	Major Paper 3 (Practical)	Lab Course on Organic Chemistry I	4	4	50	50	100
	23ScChO314	Major Paper 4 (Theory)	Organic Reaction Mechanism	2	2	25	25	50
Major Electives (4)	23ScChOP321	Major Elective (T+P)	2D Spectroscopy of Organic Compounds (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP322	Major Elective (T+P)	Protection and Deprotection of Organic Compounds (T + P)	6	4	50	50	100
RP (4)	23ScChOP351	RP	Research Project	8	4	50	50	100
OJT (4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

Semester 4

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScChOP411	Major Paper 1 (Theory)	Retrosynthesis and Advanced Synthesis of New Reagents	4	4	50	50	100
	23ScChOP412	Major Paper 2 (Theory)	Natural Products	4	4	50	50	100
	23ScChOP413	Major Paper 3 (Practical)	Lab Course on Organic Chemistry II	4	4	50	50	100
Major Electives (4)	23ScChOP421	Major Elective (T+P)	Chiron approach (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP422	Major Elective (T+P)	Biogenesis (T + P)	6	4	50	50	100
RP (4)	23ScChOP451	RP	Research Project	12	6	75	75	150
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

OE: Open Elective

CC: Co-Curricular Courses

FP: Field Project

AEC: Ability Enhancement Course

IKS: Indian Knowledge System

VSC: Vocational Skill Courses

VEC: value Education Courses

OJT: On Job Training

CEP: Community Engagement Project

Semester 3

23ScChOP311: Photochemistry, Free radicals and Pericyclic Reactions (T) (4 Credits, 60 L)

Course Outcomes

CO1: Fundamental Understanding

- Explain the basic principles, laws, and concepts of photochemistry including electronic excitation, Jablonski diagram, and quantum yield.
- Describe the generation, structure, and stability of free radicals and their role in organic reactions.

CO2: Mechanistic Insight

- Analyze and write detailed mechanisms of photochemical reactions of carbonyl compounds, alkenes, and aromatic systems.
- Elucidate free radical reaction mechanisms such as substitution, addition, and polymerization processes.
- Interpret mechanisms of pericyclic reactions including electrocyclic, cycloaddition, and sigmatropic rearrangements.

CO3: Orbital Symmetry & Theoretical Concepts

- Apply Frontier Molecular Orbital (FMO) theory and Woodward–Hoffmann rules to predict reaction feasibility.
- Explain orbital symmetry conservation and stereochemical outcomes in pericyclic reactions.

CO4: Predictive & Analytical Skills

- Predict products, stereochemistry, and reaction pathways for photochemical and pericyclic reactions.
- Correlate structure, stability, and reactivity of free radicals with reaction outcomes.

CO5: Application in Organic Synthesis

- Apply photochemical, radical, and pericyclic reactions in designing synthetic routes.
- Demonstrate the use of these reactions in industrial, biological, and environmental processes.

CO6: Problem Solving & Critical Thinking

- Solve advanced problems related to reaction mechanisms and stereochemical predictions.
- Evaluate reaction conditions (thermal vs photochemical) and choose appropriate pathways.

CO7: Advanced Learning & Research Orientation

- Develop the ability to interpret modern literature related to photochemistry and radical chemistry.
- Build a foundation for research in synthetic organic chemistry and reaction mechanisms.

Chapter 1	**Introduction**	**15 L**
	• Formation, stability and detection of long and short-lived radicals. Homolysis and free radical displacement, addition and rearrangements, Radical cyclisation in synthesis. Ref. 1, 2, 3	
Chapter 2	Photochemistry	**15 L**
	• General principles, photochemistry of carbonyl compounds, aromatic compounds, alkenes and dienes. Ref. 2, 4	
Chapter 3	**Application of photochemical reactions in synthesis**	**05 L**
	• Isocumene, Cedrene, Ladderane and Vitamin D3, Ref. 8, 9, 10, 11, 12,13	
Chapter 4	**Pericyclic reactions**	**20 L**
	• Analysis (correlation diagrams, FMO approach, ATS concept) and examples of electrocyclic, cycloaddition, sigmatropic reactions and ene reactions. Ref. 2, 5, 6, 7	
Chapter 5	**Application of Pericyclic reactions in synthesis**	**05 L**
	• Endiandric acids A – D. Ref. 8	

References:

1. Mechanism and structure in Organic Chemistry – E. S. Gould (Holt, Rinehart and Winston)
2. Advanced Organic Chemistry, Part A – F. A. Carey and R. J. Sundberg, 5th Ed. Springer (2007).
3. Radicals in Organic Synthesis B. Giese, Pergamon press (1986)
4. Organic photochemistry: A visual approach-Jan Kopecky, VCH publishers (1992).
5. Excited states in Organic Chemistry- J.A. Barltrop and J.D.Coyle, John Wiley & sons
6. Conservation of orbital symmetry – R. B. Woodward and R. Hoffmann; Verlagchemie, weinheim (1970).

7. Orbital Symmetry: A problem-solving approach- R. E. Lehr and A. P. Marchand; Academic (1972).
8. Organic reactions and orbital symmetry, 2nd Ed. T. L. Gilchrist and R. C. Storr; Cambridge University Press.
9. Classics in total synthesis- K. C. Nicolaou and E. J. Sorensen; VHC (1996)
10. P. A. Wender and J. J. Howbert J. Am. Chem. Soc. 103, 688-690 (1981)
11. Henning Hopf et al Eur. J. Org. Chem., 567-581, (2005) and references cited therein.
12. G.Mehta, M.B.Viswanath et al Angew Chem, 104, 1557-1558 (1992) and references cited therein
13. D.H.R. Barton et al J. Am. Chem. Soc. 95(8), 2748-2749 (1973).
14. Henning Hopf, Angew.Chem.Int.Ed. 42, 2822-2825 (2003).

23ScChOP312: Heterocyclic Chemistry (T) **(4 Credits, 60 L)**

Course Outcomes

CO1: Learn the structures, nomenclature rules, and classifications of heterocyclic compounds.

CO2: Understand advanced synthetic methodologies to design and execute the synthesis of various heterocyclic compounds.

CO3: Predict the molecular properties, electronic structures, and the reactivity of heterocyclic systems.

CO4: Distinguish the reactivity of heterocycles, elucidating reaction mechanisms and their pathways.

CO5: Evaluate the heterocyclic compounds with other organic compounds.

CO6: Summarize the significance and applications of heterocyclic chemistry.

Chapter 1	**Nomenclature and structure of Heterocyclic Compounds:**	**02 L**
	• Systematic nomenclature (Hantzsch-Widman System) for monocyclic, fused and bridged heterocycles.	
Chapter 2	**Five membered Heterocyclic Compounds & Condensed five membered Heterocycles**	**14 L**
	• Pyrrole, Thiophene and Furan. Knorr synthesis, Paal Knorr synthesis, Hantzsch synthesis, Tromifov synthesis from oximes & alkynes,	

	FiestBenary synthesis, Hinsbergthiophene synthesis, use of acetylene dicarboxylate esters in synthesis • Reactions:1) Electrophilic substitution 2) Nucleophilic and radical substitution 3) Ring Cleavage • Indole, Benzofuran, Benzothiophene • Synthetic approaches: i) Fischer Indole synthesis ii) Madelung's synthesis iii) Reissert'sIndole synthesis iv) Nenitzescu synthesis v) Bischler Indole synthesis vi) Synthesis of Benozofuran from Coumarin vii) Claisen Rearrangement viii) Synthesis of Benzothiophenes&Benzofuran – i) Ring synthesis from 2-Arylthio or aryloxy-aldehydes or ketones or Acids from 2-(ortho-hydroxy or mercapto aryl) Acetaldehydes-ketones or acids.	
Chapter 3	**5- and 6-Membered heterocycles containing two hetero atoms**	**15 L**
	• Synthesis and reactivity of oxazole, thiazole, imidazole, iso-oxazole, isothiazole. Heterocycles with Nitrogen-ring junction: Synthesis and reactivity of Quinolizines, Indolizines and Imidazopyridines. • Synthesis of 1,2 azoles From 1,3 dicarbonyl compounds or precursors, 1.3 dipoloarcycloaddition of nitrile oxides & nitrile imines. Synthesis of 1,3 azoles From α halocarbonyl compound or an equivalent, dehydration of α acylamino carbonyl compounds, using isocynates. • Reactions: Electrophilic substitution, Nucleophilic and radical substitution, quaternary azolium salts reactions. • Introduction to heterocycles containing three hetero atoms	
Chapter 4	**Quinoline & Isoquinoline:**	**05 L**
	• Synthetic Approaches: Skraup, Friedlander &Pfitzingr, Bischler-Napieralski, Pictet-spengler, Pomerantz-Fritsch synthesis. • Reactions: Electrophilic substitution, Nucleophilic and radical substitution, side chain reactivity.	
Chapter 5	**Pyridine group**	**04 L**

	• Synthesis: Hantzsch and Guareschi synthesis. • Reactions: Electrophilic substitution, Nucleophilic substitution reaction of Pyridine N oxide.	
Chapter 6	**Synthesis of medicinally important heterocyclic compounds**	**10 L**
	• Ranitidine,Lansoprazole and/or recently discovered molecules containing multiple hetero atoms and rings. • Synthesis of few heterocyclic novel natural products.	

References:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley, 2010.
2. Principles of Modern Heterocyclic Chemistry by Paquette.
3. The essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication
4. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York, 1968.
5. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London, 1978.
6. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees). Vol 1-8, Pergamon Press, 1984.
7. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press, 1985.
8. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic Press, 1974.
9. Heterocyclic Chemistry by Gilchrist, T. L.,3rd ed.; Addison Wesley Longman: Edinburgh Gate.

23ScChOP313: Lab Course on Organic Chemistry I (P) **(4 Credits, 30 P)**

Course Outcomes

CO1: understand the concept of type determination and apply separation techniques.

CO2: comprehend different purification techniques.

CO3: accurately record and report physical constants.

CO4: analyze microscale chemical elemental analysis.

CO5: evaluate and execute qualitative estimation of functional groups.

CO6: create a report on ternary mixture separation.

Practical	Separation of Ternary mixture	30 P
	• The students should perform the Separation of minimum Fifteen (15) mixtures containing three components. • The mixtures should also involve ether soluble and ether insoluble samples (2 sublimable compounds) • Detailed analysis of individual compound should be performed followed by Purification, Physical constant, TLC of all the samples	

References:

1. Practical Organic Chemistry by F. G. Mann and B. C. Saunders, 4th Edn., Pearson, 2009.
2. Practical Heterocyclic Chemistry, A. D. Fitton and R. K. Smalley, Academic Press, 2013.
3. Vogel's Text book of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith and A. R. Tatchell, 5th Edn., Pearson, 2003.
4. Organic Synthesis Collective, Volume I to XII, edited by J. B. Freeman, W. E. Noland, A. H. Blatt, N. Rabjohn, H. E. Baumgarten and C. K. Zercher, Wiley, 2015.
5. Macroscale and Microscale organic experiments by K. L. Williamson and K. M. Masters, 5th Edn., Books/Cole, 2016.
6. The Systematic Identification of Organic Compounds by Ralph L. Shriner, Christine K. F. Hermann, Terence C. Morrill and David Y. Curtin, 8th Edn., Wiley, 2004.
7. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia and Renu Aggarwal, Sangam Books Ltd., 2001.

23ScChO314: Organic Reaction Mechanism (T) (2 Credits, 30L)

Course Outcomes

CO1: Acquire familiarity with fundamental organic reaction mechanisms and stereochemistry principles.

CO2: Gain a comprehensive understanding of Theoretical Concepts to Predict Reactivity and Selectivity.

CO3: Design Synthetic Routes and Strategies.

CO4: Analyze the products of different organic reactions.

CO5: Solve Complex Organic Chemistry Problems based on Organic Reaction Mechanism.

CO6: Apply concepts of reaction mechanisms.

Chapter 1	**Non-kinetic Methods for determining Reaction Mechanisms**	**06 L**
	• Reaction mechanism, energy profile diagram, Product analysis, Testing & Trapping of intermediate, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect), crossover experiments and stereochemical evidence	
Chapter 2	**A) Carbanions in organic Chemistry** **B) Enamines and Imines in Organic Synthesis**	**16 L**
	• Ionization of carbon hydrogen bond and prototopy, Base and acid catalyzed halogenation of ketones, keto-enol equilibria, structure and rate in enolisation, concerted and carbanion mechanism for tautomerism, carbanion character in phenoxide and pyrrolyl anions, hydrolysis of haloforms, Aldol, Mannich, Cannizzaro, Darzens, Dickmann, Claisen Baylis-Hillman reactions, Knoevenagel, benzoin condensation, alkylation of enolates and stereochemistry thereof, Conjugate additions	
Chapter 3	**Hammett equation**	**8 L**
	• Hammet plots, Hammet equation, substituent constants, reaction constants, use of Hammet plots, +ve, -ve rho values, reaction with small -ve rho values, interpretation of mechanism using rho values, calculation of k and K, Deviations from straight line plots, Taft equation, solvent effects.	

References:

1. Mechanism and structure in Organic Chemistry – E. S. Gould (Holt, Rinehart and Winston)
2. Advanced Organic Chemistry by J. March, 8th Ed.
3. Advanced organic chemistry. F. A. Carey and R. J. Sundberg, 5th Ed. Springer (2007)
4. Organic Synthesis-by Michael B. Smith Third Edition
5. A guidebook to mechanism in organic chemistry – Peter Sykes 6th Ed. Orient Longman
6. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers. Oxford University Press
7. The Hammett Equation by C. D. Johnson, Cambridge University Press

23ScChOP321: 2D Spectroscopy of Organic Compounds (T+P) (4 Credits, 30L, 15 P)

Theory (2 Credits, 30L)

Course Outcomes

CO1: Learn the fundamental knowledge of 2D NMR and Mass Spectral techniques.

CO2: Acquire advanced knowledge of 2D NMR and Mass Spectral techniques.

CO3: Apply the knowledge of 2D NMR and Mass Spectral techniques for structure determination.

CO4: Discuss probable spectral signals.

CO5: Interpret different types of spectra.

CO6: Deduce the structure of the unknown compound using 2D NMR and Mass Spectra.

Chapter 1	**2D NMR Spectroscopy in structure elucidation:**	**14 L**
	• Pulse sequence in 1D and 2D spectra, type of 2D (Homo and Hetero nuclear); • 2D in structure determination: 1H-1H Correlation spectroscopy (COSY), Double Quantum Filtered COSY (1H-1H), Heteronuclear Correlation (HETCOR, HMQC and HMBC); • Applications: INADEQUATE, totally correlated spectroscopy (TOCSY), NOESY and ROESY experiments.	
Chapter 2	**Mass Spectrometry**	**08L**
	• Instrumentation, various methods of ionization: Gas phase ionization (electron impact and Chemical) Desorption ionization (field desorption, FAB, Plasma, Laser), Evaporative ionization (Thermospray and Electrospray mass spectrometry); • Detectors: Quadrupole mass filter, time of flight (TOF); • EI mass spectra interpretation: intensity of molecular ion peak, base peak, fragment ion peak and isotope peak (M+1, M+2); Nitrogen Rule, • Fragmentation Pattern and McLafferty rearrangement. Fragmentation of functional groups: Hydrocarbons, Ether, Aldehyde, Ketone, Carboxylic Acid, Ester, Amide, Sulphur and halogen compounds. • Application of Mass spectrometry: Molecular formula determination (Rule of	

	13).	
Chapter 3	**Structure Elucidation**	**08 L**
	• Structure elucidation using UV, IR, 1D (1H and13C) NMR and 2D NMR (1H-1H, 13C-1H COSY/HETCOR only), APT, DEPT and MS data as well as spectra.	

References:

1. Spectrometric Identification of Organic Compounds by R. M. Silverstein, F. X.Webster, D. Kiemle, 6th Ed. John Wiley and Sons.
2. One- and Two-dimensional NMR Spectroscopy by Atta-Ur-Rehman, Elsevier (1989).
3. Structure determination of Organic compounds by E. Pretsch, P. Buhlman, and C. Affolter, Springer (2005).
4. Spectroscopy of organic molecule-PS Kalsi,Wiley, Esterna, New Delhi.
5. Introduction to Spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 5thEd. (Harcourt college publishers).
6. Organic Structures from Spectra by Field L.D. Kalman J.R. and Sternhell S. 4th Ed. John Wiley and Sons Ltd.
7. Organic Structural Spectroscopy by Joseph B. Lambert, Shurvell,Lightner, Cooks, Prentice-Hall (1998).
8. Organic Structure Analysis-Phillip Crews, Rodriguez, Jaspars by Oxford University Press (1998).
9. Mass Spectrometry Basics by Christopher G. Herbert Robert A.W. Johnstone
10. Mass Spectrometry Principles and Applications by Edmond de Hoffmann and Vincent Stroobant.
11. High-Resolution NMR Techniques in Organic Synthesis by Claridge, 3rd Ed., Wiley, 2016

Practical **(2 Credits, 15 P)**

Practical	**Structure elucidation and preparation of Report for Given UV-Vis data**
	• Plot the UV-Vis spectra for the given data, interpret the λmax and prepare a sample report file in the given format. (Any 2)
Practical	**Structure elucidation and preparation of Report for Given FTIR data**
	• Plot the FTIR spectra for the given data, identify the different functional groups and prepare a sample report file in the given format. (Any 2)

Practical	**Structure elucidation and preparation of Report for Given 1-H (1D) NMR data**
	• Analysis of given 1-H NMR spectra using softwares like Mnova or ACD Labs and prepare a sample report file in the given format. (Any 4)
Practical	**Structure elucidation and preparation of Report for Given 13-C and DEPT NMR data**
	• Analysis of given 13-C NMR spectra using softwares like Mnova or ACD Labs and prepare a sample report file in the given format. (Any 3)
Practical	**Structure elucidation and preparation of Report for Given 1-H, 13-C and DEPT NMR data**
	• Analysis of given 1-H & 13-C NMR spectra using software's like Mnova or ACD Labs and prepare a sample report file in the given format. (Any 2)
Practical	**Structure elucidation and preparation of Report for Given 2D NMR data**
	• Structure elucidation using UV, IR, 1D (1H and 13C) NMR and 2D NMR (1H-1H, 13C-1H COSY/HETCOR) (Any 2)

References:

1. Practical Organic Chemistry by F. G. Mann and B. C. Saunders, 4th Edn., Pearson, 2009.
2. Practical Heterocyclic Chemistry, A. D. Fitton and R. K. Smalley, Academic Press, 2013.
3. Vogel's Text book of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith and A. R. Tatchell, 5th Edn., Pearson, 2003.
4. Organic Synthesis Collective, Volume I to XII, edited by J. B. Freeman, W. E. Noland, A. H. Blatt, N. Rabjohn, H. E. Baumgarten and C. K. Zercher, Wiley, 2015.
5. Macroscale and Microscale organic experiments by K. L. Williamson and K. M. Masters, 5th Edn., Books/Cole, 2016.
6. The Systematic Identification of Organic Compounds by Ralph L. Shriner, Christine K. F. Hermann, Terence C. Morrill and David Y. Curtin, 8th Edn., Wiley, 2004.
7. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia and Renu Aggarwal, Sangam Books Ltd., 2001

23ScChOP322: Protection and Deprotection of Organic Compounds (T + P) (4 Credits, 30L + 15 P)

Theory (2 Credits, 30L)

Course Outcomes

CO1: Understand the concept and importance of **functional group protection** in multi-step organic synthesis.

CO2: Identify different **protecting groups** for functional groups such as alcohols, amines, carbonyls, and carboxylic acids.

CO3: Explain the **mechanisms of protection and deprotection reactions** used in organic chemistry.

CO4: Select appropriate **protecting groups based on reaction conditions**, stability, and compatibility with other functional groups.

CO5: Apply protection–deprotection strategies in the **design of complex organic syntheses**.

CO6: Analyze synthetic pathways and determine where protection/deprotection steps are necessary.

CO7: Evaluate the **advantages and limitations** of various protecting groups and methods.

CO8: Develop problem-solving skills to design efficient synthetic routes involving **selective protection and deprotection**.

Chapter 1	**Protection and de-protection of hydroxyl group, including Diols**	**04 L**
	• Ethers, Esters, Protection for 1,2 and 1,3-Diols	
Chapter 2	**Protection for Phenols and Catechols**	**06 L**
	• Protection for phenol, ethers, silyl ethers, esters, carbonates, aryl carbamates, phosphinates, sulfonates, protection for catechols, cyclic acetals and ketals, cyclic esters, protection for 2-Hydroxybenzenethiols	
Chapter 2	**Protection of amines**	**06 L**
	• Carbamates, Amides, Protection for Imindazoles, Pyrroles, Indoles and Other Aromatic Heterocycles, Protection of amide, protection of sulfonamide	
Chapter 3	**Protection of carboxyl group**	**06 L**

	• Esters, Amides and Hydrazines, Protection of Boronic Acids, Protection of Sulfonic acids	
Chapter 4	**Protection of carbonyl group**	**08 L**
	• Acetals and Ketals, Miscellaneous derivates, Monoprotection of dicarbonyl compounds	

References:

1. Greene's protective groups in organic synthesis – Peter G. M. Wuts and Theodor R. A. Green 4th Edn. Wiley-India
2. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press)
3. Modern organic synthesis-An introduction- George S. Zweifel, Michael H. Nantz.
4. Advanced Organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007)

Practical **(2 Credits, 15 P)**

Course outcomes

CO1: Understand the theoretical concepts behind organic synthesis.

CO2: Acquire the experimental skills for separation, purification, identification and synthesis of organic compounds.

CO3: Design experimental set up for performing the organic reactions.

CO4: Monitor the organic reactions and analyse the products using spectral results.

CO5: Describe the mechanistic aspects of organic reactions.

CO6: Develop problem solving ability.

Practical	**Double stage preparations (Any 15P)**
	1. Nitrobenzene to m- dinitrobenzene to m- nitroaniline 2. β- Naphthol to 2- methoxy naphthalene to 1- formyl-2- methoxy naphthalene 3. Benzaldehyde to Benzalacetophenone to Epoxide 4. Resorcinol to 4-methyl-7-hydroxy to coumarin 4-Methyl-7-acetoxy coumarin 5. Hydroquinone to Hydroquinone diacetate to 1,2,4 – Triacetoxy 6. Hippuric acid to Azalactone to 4-Benzylidene 2-phenyloxazol-5-one

	7. p-Cresol to p-Cresyl benzoate to 2-Hydroxy-5-methyl benzophenone 8. Phthalimide to N-Benzylphthalimide to Benzylamine 9. Benzyl cyanide to p-Nitrobenzyl cyanide to p-Nitro phenyl acetic acid 10. Chlorobenzene to 2, 4 dinitrochlorobenzene to 2, 4 dinitro phenyl Hydrazine 11. Cyclohexanone to Enamine to 2-Acetyl Cyclohexanone 12. α-Pinene to Disiamylborane to Pinanol 13. Benzophenone to Benzophenone oxime to Benzanilide 14. Acetophenone to Benzalacetophenone to Epoxide 15. Benzoin to Benzil to Benzilic acid 16. Cyclohexanone to Phenyl hydrazone to 1, 2, 3, 4-Tetrahydro carbazole 17. Phthalic anhydride to Phthalimide to Anthranilic Acid 18. Benzyl cyanide to p-Nitrobenzyl cyanide to p-Nitro phenyl acetic acid 19. Phthalimide to N-Benzylphthalimide to Benzylamine 20. O-Nitroaniline to O-Phenylenediamine to Benzimidazole

References:

1. Vogel's Textbook of Practical Organic Chemistry" by A.I. Vogel
2. Practical Organic Chemistry: Mann and Saunders 4th edition.
3. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal
4. The synthesis, identification of organic compounds –Ralph L. Shriner, Christine K.F. Hermann, Terence C. Morrill and David Y. Curtin

23ScChOP351: Research Project (4 Credits)

Course Outcomes

CO1: Demonstrate the ability to identify a research problem in areas of organic, inorganic, analytical,
or physical chemistry through literature survey.

CO2: Apply fundamental principles of chemistry to design and execute experimental work using appropriate methodologies and techniques.

CO3: Perform laboratory experiments safely and systematically, including proper handling of chemicals, instruments, and waste disposal.

CO4: Collect, analyze, and interpret experimental data using basic statistical and analytical tools.

CO5: Use modern instruments and techniques such as spectroscopy, chromatography, or titrimetric methods relevant to the project.

CO6: Develop skills in scientific writing by preparing a well-structured project report including abstract, methodology, results, and references.

CO7: Present research findings effectively through oral presentations, posters, or seminars using appropriate scientific language.

CO8: Demonstrate critical thinking, problem-solving ability, and independent learning during the course of the project.

CO9: Understand research ethics, plagiarism issues, and proper citation of scientific literature.

CO10: Work collaboratively (if group project) and manage time efficiently to complete the research work within the given schedule.

Semester 4

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScChOP411	Major Paper 1 (Theory)	Retrosynthesis and Advanced Synthesis of New Reagents	4	4	50	50	100
	23ScChOP412	Major Paper 2 (Theory)	Natural Products	4	4	50	50	100
	23ScChOP413	Major Paper 3 (Practical)	Lab Course on Organic Chemistry II	4	4	50	50	100
Major Electives (4)	23ScChOP421	Major Elective (T+P)	Chiron approach (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP422	Major Elective (T+P)	Biogenesis (T + P)	6	4	50	50	100
RP (4)	23ScChOP451	RP	Research Project	12	6	75	75	150
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

Semester 4

23ScChOP411: Retrosynthesis and Advanced Synthesis of New Reagents (T) (4 Credits, 60 L)

Course Outcomes

CO1: Understand the concept of synthons and functional group interconversion

CO2: Understand disconnection approach in retrosynthesis

CO3: Understand regioselectivity and disconnection approach for heterocyclic systems

CO4: Understand the ways of advanced synthesis of new regents

Chapter 1	**Retrosynthesis**	**20 L**
	• Introduction to retrosynthesis (disconnection approach). Concept of synthons and reagents,functional group interconversion (1) • Synthesis of aromatic compounds in view of order of events in the chemical synthesis (1) • One group and two group carbon-heteroatom disconnection: chemoselectivity and umpolung concept and synthetic equivalents (3) • Disconnection approach for amines, ethers, alcohols, sulfides; introduction of protecting groups and stereoselectivity in retrosynthesis (4) • Disconnection approach for carbonyl compounds and regioselectivity (3) • Disconnection approach for heterocyclic systems: (a) furan (b) thiophene (c) pyrrole (d) indole (e) pyrazoles (f) pyridine (g) quinoline (h) isoquinoline (i) imidazoles (j) diazines. (8)	
Chapter 2	**Advanced Synthesis of New Reagents: C-C Bond**	**20 L**
	• Formation of simple Carbon-Carbon bonds: Carbanions of type d^1. Carbanions of type d^2: synthesis from enolates. Alkylation. Alkylation of compounds with active methylenes. Alkylation of 1,3-dicarbonyl compounds. Aldolic condensation. Michael type additions. Carbanions of type d: syntheses from organometallic compounds: organolithium and organomagnesium compounds. Organocuprates. Substitutions, additions	

	and conjugate additions. Coupling reactions catalyzed by palladium. Reactions with p-allyl palladium complexes. ● Formation of multiple carbon-carbon bonds: Alkene syntheses. Elimination reactions. Condensation of carbonyl compounds with ylide and other carbanions. Syntheses mediated by metallic carbenes, metathesis reactions. Alkyne syntheses. Elimination reactions. Condensation reactions.	
Chapter 3	**Carbene and Cyclization Chemistry**	**10 L**
	● Formation of cyclic compounds: Syntheses mediated by metallic carbenes, Cyclopropanes: Carbene additions. Cyclopentanes. Cyclohexanes and cyclohexenes: cycloadditions [4+2]. Robinson annelation. Ring closing metathesis (RCM).	
Chapter 4	**Oxidation and Reduction of Organic Compounds**	**10 L**
	● Oxidations and reductions: Alcohol oxidations. Oxidations with Cr (VI), Oxidations with RuO_4. Oxidations with DMSO. Dess-Martin oxidation. Alkene oxidations. Dihydroxylation of alkenes. Epoxydation of alkenes. Oxidative cleavage of alkenes and glycols. Baeyer-Villiger oxidation. Other oxidations. Catalytic hydrogenation. Hydrogenations in absence of hydrogen. Reductions with metallic hydrides of group 13 (B, Al). Reductions with active metals. Deoxygenation of carbonyl compounds. Other reductions.	

References:

1. Organic Synthesis, 3rd Ed., by M. B. Smith, McGraw Hill Higher Education, (2010).
2. Organic Synthesis: The Disconnection Approach, 2nd Ed. by S. Warren and P. Wyatt, John Wiley and Sons, (2008).
3. Organic Chemistry, 2nd Ed. by J. Clayden, N. Greeves and S. Warren, Oxford University Press, (2012).
4. Carey B. F. A., Sundberg R.J., (2007). Advanced Organic Chemistry Part A and Part B, Springer, 5th edition.
5. W. CARRUTHERS (2004), Modern Methods of Organic Synthesis, 4th Edition.

23ScChOP412: Natural Products (T) **(4 Credits, 60 L)**

Course Outcomes

CO1: Learn the fundamental aspects and knowledge of natural products.

CO2: Know the different pathways and biogenesis of natural products

CO3: Apply the gained knowledge in the synthesis of natural products.

CO4: Categorize the organic functional group transformations in their synthesis.

CO5: Interpret the logical retrosynthetic analysis.

CO6: Design the mechanism and stereochemistry of Natural products.

Chapter 1	**Chemistry of Natural Products**	**25 L**
	• Terpenoids: Melvalonate Pathway, Hemiterpenes, Monoterpenes, Irregular monoterpenes, Iridoids, Sesquiterpenes, Diterpenes, Sesterterpenes. • Steroids: Sterols and bile acids, estrogens, androgens, gestogens and adrenocortical hormones. Hormone production. Cardiac glycosides. Steroidal triterpenes	**10 L**
	• Alkaloids: Characteristic reactions, general methods of degradation, structure and chemistry of some well-known alkaloids. • Alkaloids derived from ornithine: Polyamines, Pyrrolidine and tropane alkaloids, Pyrrolizidine alkaloids, • Alkaloids derived from lysine: Piperidine alkaloids, Quinolizidine alkaloids, Indolizidine alkaloids • Alkaloids derived from nicotinic acid: Pyridine alkaloids, • Alkaloids derived from tyrosine: Phenylethylamines, simple and modified tetrahydroisoquinoline alkaloids, Amaryllidaceaealkaloids, • Alkaloids derived from tryptophan: Simple indole alkaloids, Simple β-carboline alkaloids, Terpenoids indole alkaloids	**10 L**
	• Natural Pigments: Flavones, flavanones, isoflavones, xanthones, quinones, pterins, chlorophyll and haemin.	**05L**

	• Carbohydrates: Stereochemistry, reaction and conformation of monosaccharides, deoxy and aminosugars, hexonic acid and vitamin C, disaccharides, polysaccharides, inositol; gan-gliosides and other glycosides. Chemistry of vitamins A,B,C and E.	
Chapter 2	**Total Synthesis of Natural Products**	**15 L**
	• Structure determination and Synthesis of i. Reserpine (Woodward synthesis) ii. Taxol iii. Estrone and Mifepristone iv. Strychnine (Overman's synthesis) v. Fredericamycin A	

References:

1. I. L. Finar, *Organic Chemistry, Vol .2*, 5th edition, ELBS, 1975.
2. K. Nakanishi, T. Goto, S.Ito, S. Najori and S. Nozoe, *Natural products Chemistry*, *Vol. 1and 2*, Academic Press, 1974.
3. A. A. Newman, *Chemistry of Terpenes and Terpenoids*, Academic Press, 1972.
4. W. Pelletier, *Chemistry of the Alkaloids*, Van Nostrand Reinhold, 1970.
5. W.Shoppee, *Chemistry of the Steroids*, 2nd edition, Butter worths, 1964.
6. D. Guthrie and J. Honeyman*, An Introduction to the Chemistry of Carbohydratres*, 3rd edition, Clarendon Press, 1968.
7. A. Geissman, *Chemistry of Flavonoid Compounds*, Pergamomn Press, 1962.
8. Medicinal Natural Products - A Biosynthetic approach by Paul M. Dewick 3rd Ed. (Wiley)
9. Secondary metabolism - J. Mann, 2nd edition.
10. Chemical aspects of Biosynthesis – J. Mann (1994).

23ScChOP413: Lab Course on Organic Chemistry II (P) **(4 Credits, 30 P)**

Course Outcomes

CO1: Learn new synthetic methodologies for the selective modification of starting materials.

CO2: Recognize the reactivity of starting materials towards different reagents and reaction conditions.

CO3: Apply multi-step synthesis strategies to construct complex molecules from simple starting materials.

CO4: Analyze reaction mechanisms and intermediates to understand the synthesis pathways.

CO5: Evaluate the efficiency and practicality of different synthetic routes based on yield and selectivity.

CO6: Create novel synthesis routes based on the principles of organic chemistry and reactivity patterns.

Practical	Three Stage Preparations	30 P
1	Synthesis of N, N-disubstituted indigo Step I: o-Nitrotoluene to o-Nitrobenzaldehyde (MnO_2 OXIDATION) Step II: o-Nitrobenzaldehyde to Indigo (acetone and NaOH) Step III:Indigo to N, N-disubstituted indigo (oxalyl chloride)	
2	Synthesis of Benzilic acid Step I: Benzaldehyde to Bezoin (Thiamine HCl) Step II: Benzoin to Benzil (HNO_3) Step III:Benzil to Benzilic acid (KOH)	
3	Synthesis of Dialtin Step I: Benzaldehyde to Bezoin (Thiamine HCl) Step II: Benzoin to Benzil (HNO_3) Step III:Benzil to Benzilic acid (Urea, KOH, H_2SO_4)	
4	Synthesis of Methyl salicylate Step I: Phenol to Salicyldehyde (NaOH, $CHCl_3$) Step II: Salicyldehyde to Salicylic acid ($K_2Cr_2O_7$) Step III:Salicylic acid to Methyl salicylate(Methanol, H_2SO_4)	
5	Synthesis of N-phenyl benzamide Step I: Benzoyl chloride to Benzamide (NH_3) Step II: Benzamide to Aniline (NaOH, Br_2) Step III:Aniline to N-methyl benzamide (Benzoyl Chloride, Base)	

6	Synthesis of Benzaldehyde Step I: Benzoic acid to ethyl benzoate (esterification) Step II: Ethyl benzoate to Benyl alcohol ($NaBH_4$, MeOH) Step III:Benyl alcohol to Benzaldehyde (MnO_2)	
7	Synthesis of N-acetyl-4-amino phenol Step I: 4-chloronitrobenzene to 4-Nitrophenol (NaOH) Step II: 4-Nitrophenol to 4-amino phenol ($NaBH_4$, CuO) Step III: 4-amino phenol to N-acetyl-4-amino phenol (Acetyl chloride)	
8	Synthesis of Schiff base of m-phenylene diamine Step I: Nitrobenzene to m-DNB (Nitration) Step II: m-DNB to m-dibenzenamide (Sn-HCl) Step III: m-dibenzenamide to Schiff Base (Using Salicyldehyde)	
9	Synthesis of p-bromoaniline Step I: Aniline to acetanilide (acetylation) Step II: Acetanilide to p-bromoacetanilide (Bromination) Step III: p-bromoacetanilide to p-bromoaniline (hydrolysis)	
10	Synthesis of Flavone Step I: o-hydroxy acetophenone to benzoylated o-hydroxy acetophenone (Benzoylation) Step II: Benzoylated o-hydroxy acetophenone to diketone (BV rearrangement) Step III: Diketone to flavone (cyclization)	
11	Synthesis of p-nitroaniline Step I: Aniline to acetanilide (acetylation) Step II: Acetanilide to p-nitro acetanilide (Nitration) Step III: p-nitro acetanilide top-nitroaniline (hydrolysis)	

References:

1. Ahluwalia, V. K. and Aggarwal, R. (2000). Comprehensive practical organic chemistry: Preparation and Quantitative Analysis, Universities Press
2. Vogel's Textbook of Practical Organic Chemistry" by A.I. Vogel
3. Practical organic Chemistry: Mann and Saunders 4th edition.
4. Experimental Organic Chemistry: A Miniscale & Microscale Approach" by John C. Gilbert and Stephen F. Martin

5. Advanced Practical Organic Chemistry - N. K. Vishnoi - Vikas 2nd Ed., (1996)
6. Katritzky, Alan R., et al. Handbook of heterocyclic chemistry. Elsevier, 2010.
7. Practical heterocyclic chemistry Fitton, Alan Ogden, and Robert Kenneth Smalley.

23ScChOP421: Chiron approach (T + P) (4 Credits, 30L + 15 P)

Theory **(2 Credits, 30L)**

Course Outcomes

CO1: Understand cyclic hemiacetal forms and anomeric configurations.

CO2: Applying Chiron approaches, they'll design syntheses of complex chiral molecules

CO3: Analyze protective group strategies between temporary and permanent groups

CO4: Summarize the planning of synthesis, pathways for chiral compound synthesis

Chapter 1	**Chiron approach**	**10 L**
	• Different strategies for asymmetric synthesis • Introduction of chiron approach • The concept of chiral auxiliary and chiral templates • Utilization of the basic chirality concepts in total synthesis of: (S) Propanediol (R) and (S) – Epichlorohydrin L (+)-Alanine, (-) Multistratin (-) Pentenomycin prostaglandin (-) Shikimic acid • Chiral Drugs: Introduction of chiral drugs, Eutomer, Distomer and eudesmic ratio. a) with no side effects b) with undesirable side effects Synthesis and pharmacological activity of S Ibuprofen, S-Metaprolol, Indinavir sulfate, Dextropropoxyphen, (+)-Ephedrine, Griseofulvin, R-Indacrinnone, hydrochloride, S-Captopril	
Chapter 2	**Applications of Chiron approaches**	**20 L**

	• Asymmetric catalysis: Stereoselective catalytic reduction-homogeneous hydrogenation (chiral ligands, effect of solvent/ pressure/ temperature/ addendum, substrate dependence of enantioselectivity, mechanistic aspects), stereoselective heterogeneous hydrogenation, transfer hydrogenation, hydrosilylation,hydrocynation, stereoselective oxidation enantio / diastereoselectiveepoxidation and dihydroxylation. • Concepts on catalytic asymmetric induction: Ligand accelerated catalysis; Self replication of chirality-catalytic self-replicating molecules, control of chirality memory, P stacking effect, selectivity and mechanism of catalytic asymmetric synthesis. • Stereoselective C-C bond formation: Nucleophilic addition to C=X(X=C, O, S, N), Stereoselective hydroformylation, Pericyclic reaction asymmetric induction in [3+2] and [2+2] cycloaddition, stereoselective carbene addition, chirality transfer in sigmatropic rearrangements. • Determination of enantiomeric purity: Various tools, chiral derivatising agents, chiral shift reagents, chiral solvating agents.	

References:

1. Modern organic synthesis-An introduction- George S. Zweifel, Michael H. Nantz.
2. Chiron Approach in organic synthesis – S. Hanessian
3. Advanced Organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007)

Practical **(2 Credits, 15 P)**

Course Outcomes:

CO1: Understand and explain the mechanisms of different rearrangement reactions such as Pinacol, Beckmann, and Hofmann rearrangements.

CO2: Perform laboratory synthesis involving rearrangement reactions with proper experimental techniques and safety measures.

CO3: Analyze the migration aptitude of substituents in rearrangement reactions and predict major products.

CO4: Analyze the migration aptitude of substituents in rearrangement reactions and predict major products.

CO5: Apply knowledge of rearrangements in designing synthetic routes and solving advanced organic chemistry problems.

Practical	Practicals based on Rearrangement reactions	30 P
	1. Baker- VenkataramanRearrangement:Benzyolatedactephenone to diketone (using base) 2. Benzoin Condensation: Bezaldehyde to Benzoin (Thiamine HCl and NaOH) 3. Beckmann Rearrangement: Benzophenone to Benzanilide (Hydroxylamine HCl) 4. Benzil- Benzilic Acid Rearrangement (NaOH) 5. Bayer Villiger rearrangement: Cyclohexanone to Caprolactone 6. Hoffman rearrangement:Benzanilide to aninile (NaOH, Br_2) 7. Pinacole-pinacolone (Acid catalyzed) 8. Claisen rearrangement: Phenyl allyl ether to o-allyl phenol (thermal) 9. Fries rearrangement: phenyl acetate to o-hydroxy acetophenone ($ZnCl_2$ catalyzed) 10. Favorskii rearrangement: 2-chlorocyclohexanone to cyclopentanoic acid (NaOH) 11. Photochemical Fries Rearrangement in methanol and sunlight (phenyl acetate to 1-acetyl-2-naphthol)	

References:

1. V.K. Ahluwalia, Renu Aggarwal *Comprehensive Practical Organic Chemistry* preparation and Quantitative Analysis
2. Vogels textbook of Practical Organic Chemistry

23ScChOP422: Biogenesis (T + P) (4 Credits, 30L + 15 P)

Theory (2 Credits, 30L)

Course Outcomes

CO:1 Describe the chemical evolution of life, including the formation of simple organic molecules from inorganic precursors.

CO:2 Correlate biogenesis concepts with modern biochemical pathways and molecular biology.

CO:3 Develop critical thinking to assess current research and advancements in origin-of-life studies.

CO:4 Explain the chemical pathways involved in the abiotic synthesis of simple organic molecules

Chapter 1	**Building blocks: construction and mechanism**	**15 L**
	• The building blocks and construction mechanism of (i) Terpenoids – Mono, Sesqui, Di and Triterpenoids and cholesterol (ii) Alkaloids derived from ornithine, lysine, nicotinic acid, tyrosine and trytophan. (iii) The Shikimate pathway – cinnamic acids, lignans and lignin, coumarins, flavonoids and stilbers, isoflavanoids and terpenoid quinones. (iv) Arachidonic acid – Prostagladins&thromboxanes.	
Chapter 2	**Biogenesis**	**15 L**
	• Structure, stereochemistry, synthesis and biogenesis of Hardwickiic acid, Camptothecin and Podophyllotoxin. • Biogenesis of some important mono (Geraniol, Menthol, α-Pinene & Camphor), sesqui (Farnesol, β-Caryophyllene, Humulene, Zingiberene) di (Phytol,Abietic Acid), and triterpenes Squalene, Lanosterol, Cycloartenol & β-Amyrin) • Biogenesis of steroids (Pregnenolone, Progesterone, Cortisol, Aldosterone, Androgens & Estrogens) and correlation with terpenoids.	

References:

1. J. Am Chem. Soc. 88, 3888 (1966).
2. M. C. Wani and M.E. Wall J. Org. Chem. 34, 1364 (1969)
3. (i) Tetrahedron Letters, 3751 (1964) (ii) Tetrahedron Letters, 2861 and 2865 (1968)
4. Chemistry of Natural products-Kalsi
5. Principles of organic synthesis by R.O.C. Norman and J. M. Coxon; Chapman and Hall

6. Classics in organic synthesis – K.C. Nicolaou and E.J. Sorensen
7. J. Indian Inst. Sci. 81, 287 (2001).
8. Medial Natural Products – A Biosynthetic approach by Paul M. Dewick 2nd edition (Wiley)
9. Secondary metabolism – J. Mann, 2nd edition.
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11. J.C.S. Perkin Transactions II, 288-292, (1973) ii) J. Am. Chem. Soc. Vol. 77, 432- 437, (1955). Apsimon: The Total synthesis of natural products.

Practical **(2 Credits, 15 P)**

Course outcomes

1. Understand the basics of computer and chemistry software
2. Demonstrate data presentation using software
3. Build the models related to chemistry
4. Apply the first principles to generate potential energy surface, hydrogen bonding, and reaction mechanism
5. Predict the structure & properties of molecules and reaction mechanisms using the tools of computational chemistry

Practical	**Practicals based on Molecule Modeling (15 Practicals)**	**30 P**
	Following parameters can be considered to perform the Practicals ● Introduction to Molecular Modeling Software ● 3D Structure Building and Optimization ● Measurement of Bond Parameters ● Conformational Analysis ● Energy Calculations & Methods ● Electronic Properties & Reactivity ● HOMO–LUMO Analysis ● Charge Distribution Analysis ● Reaction & Mechanism Studies ● Host-Guest concept	

References:

1. Handbook of Computational Chemistry, Jerzy Leszczynski, Springer, 2012.
2. Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems, David Young, Wiley, 2004.

23ScChOP451: Research Project (4 Credits)

Course Outcomes

CO1: Demonstrate the ability to identify a research problem in areas of organic, inorganic, analytical, or physical chemistry through literature survey.

CO2: Apply fundamental principles of chemistry to design and execute experimental work using appropriate methodologies and techniques.

CO3: Perform laboratory experiments safely and systematically, including proper handling of chemicals, instruments, and waste disposal.

CO4: Collect, analyze, and interpret experimental data using basic statistical and analytical tools.

CO5: Use modern instruments and techniques such as spectroscopy, chromatography, or titrimetric methods relevant to the project.

CO6: Develop skills in scientific writing by preparing a well-structured project report including abstract, methodology, results, and references.

CO7: Present research findings effectively through oral presentations, posters, or seminars using appropriate scientific language.

CO8: Demonstrate critical thinking, problem-solving ability, and independent learning during the course of the project.

CO9: Understand research ethics, plagiarism issues, and proper citation of scientific literature.

CO10: Work collaboratively (if group project) and manage time efficiently to complete the research work within the given schedule.