Abeda Inamdar Senior College of Arts, Science and Commerce, Pune 411001

(Autonomous)

Affiliated to Savitribai Phule Pune University

Syllabus for

M. Sc. Part-II

(M.Sc. Organic Chemistry)

Choice Based Credit System [CBCS]

From Academic Year 2022-23

Board of Studies (Chemistry)

Post Graduate Department of Chemistry and Research Center

Abeda Inamdar Senior College of Arts, Science and Commerce, Pune-411001.

Syllabus of Autonomous M. Sc. Part-II Organic Chemistry

Choice Based Credit System [CBCS]

[2022-23]

Structure of the Course:

Basic Frame work of the syllabus for M. Sc. Part-II Organic Chemistry at the Abeda Inamdar Senior College of Arts, Science and Commerce, (Autonomous), Pune affiliated to Savitribai Phule Pune University.

Sr. No.	Paper No.	Subject	Credit
SEMEMSTER-III			
1	21SMOC231	Organic Reaction Mechanism, Free Radical and Heterocyclic Chemistry	4
2	21SMOC232	Application of Spectroscopy to Structural Analysis	4
3	21SMOC233	Organic Stereochemistry, Pericyclic and Photochemistry reactions	4
		(Any One from Following 21SMOC234)	
4	21SMOC234A	Protection-Deprotection and Carbohydrate Chemistry	2
4	21SMOC234B	Bio-Organic Chemistry	2
5	21SMOC235	Practical: Ternary Mixture Separation	2
6	21SMOC236	Practical: Solvent Free Synthesis	2
7	21SMOC237	Practical: Double Stage Preparations	2
SEMESTER-IV			
8	21SMOC241	Retrosynthesis, Total Synthesis and Biogenesis of Natural Products	4
9	21SMOC242	Advanced Organic Synthesis	4
10	21SMOC243	Medicinal Chemistry	4
		(Any One from Following 21SMOC244)	
11	21SMOC244A	Asymmetric Synthesis	
11	21SMOC244B	Supramolecular reaction	2
12	21SMOC245	Practical: Convergent and Divergent Synthesis	2
13	21SMOC246	Practical: Carbohydrate synthesis and Isolation of Natural Compounds	2
		(Any One from Following 21SMOC247)	
14	21SMOC247A	Project / Industrial Training	2
14	21SMOC247B	Practical: PTC, Microwave assisted Organic Synthesis and Instrumental Techniques	2

***N.B.:** 1. One Credit Theory Paper = 15 Hours lectures per semester and 1 Hour per week.

2. Two Credit Practical Paper = 60 Hours practical per semester and 4 hours per week.

M. Sc. II Organic Chemistry Programme Objectives and Outcomes

Programme Objectives:

1. To develop conscience towards social responsibility, human values and sustainable development through curriculum delivery and extra-curricular activities.
2. To develop scientific temperament with strong fundamental knowledge of the subject.
3. To develop analytical thinking and problem-solving skills needed for various entrance and competitive examinations and Post Graduate Studies.
4. To train students in laboratory skills and handling equipment along with soft skills needed for placement.
5. To mold a generation of youth this can apply the chemistry in their life and careers.
6. To inculcate scientific attitude enriched with a multidisciplinary perspective in the students.
7. To update the students with the needs of the industry and society with respect to chemistry.

Programme Outcomes: After completing the M. Sc. Programme, the students shall:

1. Know the basics and applied aspects of the chemistry.
2. Be in a position to apply their knowledge in their professional, social and personal life.
3. Be competent to pursue research or a career in the chemistry.
4. Have the knowledge and confidence to pursue higher studies in Chemistry.
5. Have skills in laboratory techniques and experience in instrument handling.
6. Develop sensitivity towards social issues and become productive citizens of the nation.

Programme Specific Outcome:

M.Sc. Organic Chemistry:

1. Should gain knowledge in basic organic chemistry, re-arrangements, modern synthetic reagents, coupling reaction, multicomponent synthesis and click chemistry reactions.
2. Students should be able to gain knowledge in classical organic laboratory techniques and the uses of modern instrumentation to perform new experiments.
3. Should be able to understand Advanced Spectroscopic Techniques, Stereochemistry, Organic Synthesis and basics of Computer Aided Drug Designing as well.

4. Should acquire the ability to synthesize, separate and characterize compounds using laboratory and instrumentation techniques.
5. Should be able to integrate the knowledge learned in Organic Chemistry to various industrial and pharmaceutical needs.
6. Learn about the potential uses of retro-synthetic analysis, medicinal chemistry, natural products chemistry and green chemistry.
7. Should be able to shoulder responsibilities in R & D labs.
8. To interpret the data obtained from various spectral techniques, through theoretical principals.
9. Able to apply knowledge of organic chemistry in research problems.
10. Should know about global level research opportunities to pursue Ph.D. programmes, targeted approach of CSIR – NET and other competitive examinations.
11. Should know enormous job opportunities at all levels of chemical, pharmaceutical, food products, life-oriented material industries.

Evaluation Pattern:

For each Theory and Practical Course, 50-50 pattern will be followed. Internal assessment will be of 50 marks for a paper of 100 Marks. Internal assessment will be of 25 marks for a paper of 50 Marks.

For Continuous Internal Evaluation (CIE), evaluation of theory courses will be done continuously. The 50 marks of Internal Evaluation shall be divided into the following:

a) One Mid Semester Exams of 15 Marks each.
b) Two Class Tests of 15 marks each converted to 15 Marks.
c) One Presentation/Seminar/MCQ Test of 5 Marks.
d) One Group Discussion/Open Book Test of 5 or 10 Marks.
e) Class Assignments of 10 or 5 Marks.
f) A compulsory Mock Practical Examination and Viva Voce of practical subjects.
g) Internal marks for Journal / project report/ dissertation report completion and certification.

M. Sc. Part-II Organic Chemistry

SEMESER-III

Course/ Paper Title	**Organic Reaction Mechanism, Free Radical and Heterocyclic Chemistry**
Course Code	21SMOC231
Semester	III
No. of Credits	4 Credits, (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
	Student should understand and learn;
1.	The student is expected to learn the basic theory of organic reaction mechanism.
2.	The course has been designed such that it will be helpful in understanding the qualitative and quantitative impacts of the substituents on reaction mechanism.
3.	Through this course, student is expected to thoroughly learn basic as well as advanced concepts and various reactions of carbanion, free radicals with their applications in organic syntheses.
4.	The course will give a fundamental theoretical understanding of heterocyclic chemistry, including alternative general methods for ring synthesis and application of such methods for the preparation of specific groups of heterocyclic systems.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Student should be able to;
1.	To inculcate mechanistic approach for advanced organic reactions.
2.	Students will be able to correctly identify the electronic effects of various important substituents during course of the reaction.

3.	Theoretical understanding of heterocyclic chemistry which includes various methods for ring synthesis and application of those methods for the preparation of specific groups of heterocyclic systems.
4.	Students will be able to draw mechanisms for reactions involving heterocycles as starting materials, intermediates and products, and be able to propose syntheses of heterocycles from the major classes.

Section-I: Organic Reaction Mechanism [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Hammett equation and its applications. Linear free energy relationship** Hammett plots, Hammett equation, substituent constants, reaction constants, use of Hammett plots, calculation of k and K, Deviations from straight line plots, Taft equation, solvent effects.	**06**
II	**Methods for determining Reaction Mechanisms (Kinetic and non-kinetic methods)**	**04**
III	**Alkylation of Nucleophilic Carbon Intermediates (Carbanions)** Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates, Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation, Alkylation of aldehydes, ketones, esters, amides and nitriles, Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction)	**06**
IV	**Reaction of carbon nucleophiles with carbonyl groups** Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, Regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol	**08**

	reaction and Robinson annulation, Addition reactions with amines and iminium ions; Mannich reaction, Amine catalysed condensation reaction: Knoevenagel reaction. Acylation of carbanions, Reactions of Phosphorous, Nitrogen and Sulphur Ylids.	

References Books:

1. Mechanism and structure in Organic Chemistry – E. S. Gould (Holt, Rinehart and Winston)

2. Advanced organic chemistry by J. March, 6th Ed.

3. Advanced organic chemistry. F. A. Carey and R. J. Sundberg, 5th Ed. Springer (2007)

4. A guidebook to mechanism in organic chemistry – Peter Sykes 6th Ed. Orient Longman

5. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers. Oxford University Press (2001)

Section-II: Free Radical and Heterocyclic Chemistry [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Free Radicals** Generation, stability, reactivity, Free radical substitution, addition to multiple bonds, radicals in synthesis, Inter- and intra-molecular bond formation via mercury hydride, tin hydride, thiol donors, cleavage of C-X, C-Sn, C-S, O-O bonds, Oxidative coupling, C-C bond formation in aromatics, SNAr reactions, Free Radicals in Organic Synthesis.	**08**
II	**Heterocyclic Chemistry** Synthesis and reactions of Five and Six Membered Hetero Cyclic Compounds- Containing One, Two and Three Hetero atoms, Synthesis and Reactions of Fused Ring Heterocyclic Compounds- Indole, Benzo Furan, BenzoThiophene, Quinoline and Isoquinoline.	**16**

Reference Books:

1. Advanced Organic Chemistry, Part A – F. A. Carey and R. J. Sundberg, 5th Ed. Springer (2007)
2. Radical in Organic Synthesis- B. Giese, Pergamon Press (1986)
3. Mechanism and structure in Organic Chemistry E. S. Gould (Holt, Rinehart and Winston)
4. Advanced Organic Chemistry –J. March, 4th edition
5. Advanced Organic Chemistry- Part A: Structure and Mechanism- F. A. Carey and R. J. Sundberg, 5th Edition, Springer 2007)
6. A guidebook to mechanism in Organic Chemistry- Peter Sykes
7. Classics in total synthesis- K. C. Nicolaou and E. J. Sorensen; VHC (1996)
8. P. A. Wender and J. J. Howbert J. Am. Chem. Soc. 103, 688-690 (1981)
9. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers
10. Heterocyclic Chemistry -T. Gilchrist 15. An introduction to the chemistry of heterocyclic compounds-R M Acheso
11. Heterocyclic Chemistry- J A Joule and K Mills
12. Principles of modern heterocyclic chemistry- A Paquette

13. Heterocyclic Chemistry- J A Joule and Smith

14. Handbook of Heterocyclic Chemistry- A R Katritzky, A F Pozharskii

15. Heterocyclic Chemistry-II- R R Gupta, M Kumar, V Gupta, Springer (India) pvt

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Course/ Paper Title	**Application of Spectroscopy to Structural Analysis**
Course Code	21SMOC232
Semester	III
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Aims and Objectives
	Student should understand and learn;
1.	The basic concept of NMR spectroscopy
2.	To apply the different aspects of NMR spectroscopy to predict the structure of Compounds.
3.	To analyze the Mass spectroscopy.
4.	To correlate the different Heteronuclear Coupling.
5.	To evaluate the invaluable tools in synthetic chemistry for the confirmation of known molecules and elucidation of structures of unknown compounds of high complexity with a high degree of certainty.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Students should be able to;
1.	Recognize the basic concept Understand the valuable concepts in NMR spectroscopy.
2.	Discuss the basic knowledge about Mass spectroscopy.
3.	Experiment the different aspects of NMR spectroscopy to predict the structure of

	compounds.
4.	Predict the structure of unknown molecules by using the spectral data and to identify the structure of the molecules.

Section-I: NMR of Proton, Carbon and other Hetero nuclei [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Nuclear Magnetic Resonance Spectroscopy** Concepts of NMR, NMR Internal interaction parameters- External and Internal interactions in NMR, Chemical Shifts, NMR Spectrum and chemical equivalence, Conversion of frequency and ppm, Field dependence and factors affecting chemical shift and Coupling constant. Coupled spin systems and multiplicity patterns of coupled spins -Coupling among non-equivalent spins, Geminal and Vicinal couplings, Spin system Nomenclature, Isotope effect, Analysis of Strongly coupled spin systems, Analysis of Three four and five nuclei (first order spectra), Roofing effect etc. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle spin coupled systems, Simplification of complex Spectra - Nuclear magnetic double resonance, solvent effects. Fourier transform technique, Nuclear Overhauser effect (NOE).	**14**
II	**^{13}C-NMR Spectra -**General considerations, chemical shift (aliphatic, olefin, alkyne, aromatic, hetero aromatic and carbonyl carbon), Coupled and Decoupled ^{13}C-Spectra, Broadband decoupling in ^{13}C-NMR, Analysis of ^{13}C spectra, DEPT and APT technique. Heteronuclear couplings and satellite analysis, Analysis of spectra of other nuclei, like ^{19}F, ^{15}N, and ^{31}P.	**10**

Section-II: Mass and Two-Dimensional Spectroscopy [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Mass Spectrometry** Instrumentation, various methods of ionization (field ionization, field desorption, SIMS, FAB, MALDI), different detectors (magnetic analyzer, ion cyclotron analyzer, Quadrupole mass filter, time of flight (TOF), factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Mc-Lafferty rearrangement. Nitrogen rule High resolution mass spectrometry.	**06**
II	**Two-dimensional (2D) Spectroscopy** 2D NMR Techniques, General idea about two-dimensional NMR spectroscopy, 2D NMR (1H-1H, 13C- 1H COSY/ HETCOR, HMBC), experiments and their applications.	**06**
III	**Structure elucidation based on spectroscopic data** (IR, UV, NMR, Mass and 2D)	**12**

Reference Books:

1. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric identification of organic compounds, 7th edition, John Wiley, 2005.

2. Organic Spectroscopy, W. Kemp, 3rd edition, Macmillan, 2011.

3. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw Hill, 6th edition 2007.

4. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th edition, New age international, 2004.

5. Introduction to Spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 3rd Ed. (Harcourt college publishers).

6. Nuclear Magnetic Resonance – Basic Principles- Atta-Ur-Rehman, Springer- Verlag (1986).

7. One and Two dimensional NMR Spectroscopy- - Atta-Ur-Rehman, Elsevier (1989).

8. Organic structure Analysis- Phillip Crews, Rodriguez, Jaspars, Oxford University Press (1998).

9. Organic structural spectroscopy- Joseph B. Lambert, Shurvell, Lightner, Cooks, Prentice-Hall (1998).

10. Organic structures from spectra- Field L. D., Kalman J.R. and Sternhell S. 4th Ed. John Wiley and sons Ltd.

11. NMR spectroscopy of Organic compounds. Jackmann and Sternhell S (1998)

12. Organic spectroscopy-RT Morrison and RN Boyd 15. Practical NMR spectroscopy-ML Martin, J J Delpench, and D J Martyin

13. Spectroscopy in organic chemistry- C N R Rao and J R Ferraro

14. NMR –Basic principle and application-H Guntur

15. Interpretation of NMR spectra-Roy H Bible

16. Mass spectrometry organic chemical applications, J H Banyon

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Course/ Paper Title	**Organic Stereochemistry, Pericyclic and Photochemistry reactions**
Course Code	21SMOC233
Semester	III
No. of Credits	4 Credits, (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
	Student should understand and learn;
1.	To learn and apply various concepts such as stereochemistry and fundamental principles of stereoselectivity in organic chemistry.
2.	To enable a comprehensive knowledge on conformational analysis and stereochemistry, concerted reactions and pericyclic reactions of organic compounds to the students.
3.	To learn conformation and reactivity of cycloalkanes, fused and brighed ring compounds, models use for diastereoselectivity
4.	To explain the stereochemical aspects of organic compounds and stereochemical reactions with stereochemistry.
5.	To develop interest and understanding of the theoretical basis for Pericyclic reactions and skills for the utilization of these reactions in the organic synthesis.
6.	To learn and understand various types of pericyclic reaction, approaches in pericyclic reaction and mechanisms

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Student should be able to;
1.	Evaluate the stability of various conformers of acyclic and cyclic systems using steric, electronic and stereoelectronic effects and correlate them to reactivity. Use various models for determining stereoselectivity of various organic transformations
2.	Able to Predict the stereochemistry & mechanism reactions.
3.	Able to predict the stereochemistry & products of the Pericyclic reactions
4.	Able to predict the correct Models for diastereoselective reaction
5.	Predict whether the pericyclic reaction will proceed under thermal or photochemical conditions

Syllabus

Section-I: Organic Stereochemistry [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Stereochemistry of six membered rings:** Conformations of polysubstituted cyclohexane, physical properties of substituted cyclohexanes, 2-alkyl and 3-alkyl ketone effect, conformations, reactivity and stereochemical principles involved in reactions of six membered rings; stereochemistry of addition, elimination, reduction, iodo-lactonization, epoxidations in six membered rings.; Conformational effects in six membered heterocyclic rings- Anomeric effect, Double anomeric effects; Study of conformers with boat and twist boat form- Cis and trans -1,3-di-t-butyl-cyclohexanes, 1,4-di-t-butyl-cyclohexanes,1-Cis-4-di-t-butyl-cis-2,5-dihydroxycyclohexane, Cis-2-methyl-5-tert-butyl-1,3-dioxane.	**07**
II	**Stereochemistry of rings other than six membered rings:** Shapes and stability of three, four, five, seven and eight membered	**04**

	rings. Conformational effects in Medium sized rings, transannular effect, Concept of I- strain, reactions in other than six membered rings	
III	**Stereochemistry of fused and bridged ring systems:** Introduction of ring systems: Nomenclature, synthesis; Stereochemistry of bicyclic compounds, Fused bicyclic compounds; Stereochemical aspects of Decalin, 9-metyl decalin, Perhydrophenanthrene, Perhydroanthracene, hydrindane, Steroids, twistane; Bridged system (bi, tri and polycyclo system) including heteroatoms; Bredt's Rule and applications with examples; reaction in bridged and fused rings; stereoselective reactions in fused and bridged rings.	**06**
IV	**Diastereoselectivity:** Cram's Model, Felkin Anh Model, dipolar model and Cram's rigid model; Houk models, Cieplak and cation coordination models.	**04**
V	**Racemic modification:** Methods of preparation and Resolution of modification; Stereochemistry of a polymer chain – Types and examples of Tacticity.	**03**

Reference Books:

1. Stereochemistry of carbon compounds - E. L. Eliel
2. Stereochemistry of carbon compounds - E. L. Eliel and S. H. Wilen
3. Stereochemistry of organic compounds - Nasipuri
4. Stereochemistry of organic compounds – Kalsi
5. Modern Organic Synthesis - An Introduction by George S. Zweifel, Michael H. Nantz
6. Principles and Applications of Stereochemistry- Michael North
7. Chemistry of Plant Natural Products-Stereochemistry, Conformation, Synthesis, Biology, and Medicine by Sunil Kumar Talapatra Bani Talapatra (Springer)

Section-II: Pericyclic and Photochemistry reactions [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Pericyclic reactions:** i) Introduction -Characteristics and classification of pericyclic reactions. ii) Molecular orbitals –Bonding and symmetry properties. iii) Woodward Hoffmann rules, Orbital analysis, Orbital Correlation Diagram, FMO approaches, PMO, Möbius–Hückel ATS concept and Stereochemistry of **Electrocyclic reactions, Cycloaddition reactions.** **iv) Electrocyclic reaction:** Torquoselectivity, Examples of electrocyclic reactions, Nazarov reaction iv) **Cycloaddition Reactions:** study of Diels-Alder reaction - orientation, Stereochemistry, Cis rule, Alder's Endo rule and Regioselectivity; 1,3-Dipolar cycloaddition, ketene addition, other examples v) **Sigmatropic rearrangements**: Stereochemistry, FMO and PMO approach, H and C sigmatropic migration, [1,3], [1,5], [1,7], [3,3] sigmatropic rearrangements- Cope, Oxy-Cope, Aza-Cope, Claisen, and Aza-Claisen rearrangements. vi) **Chelotropic reactions** (Additions and Eliminations), Group transfer, Group elimination and Ene reactions. vii) Examples based on pericyclic reactions with other reactions.	**14**
II	**Photochemistry:** Quantum yield, electronic states and transitions, modes of dissipation of energy (Jablonski diagram), electronic energy transfer. Photosensitization and quenching process, Quantum yield. **Photochemistry of carbonyl compounds:** Norrish-I and Norrish-II cleavages, Photoenolisation, Photoreduction, Paterno-Buchi reaction. Photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement. **Photochemistry of olefins:** cis-trans isomerizations, dimerizations and Di-π- methane rearrangements. **Photochemistry of Benzene** and Substituted Benzene, Barton reaction.	**10**

Reference Books:

1. The Conservation of Orbital Symmetry by R.B. Woodward and R. Hoffman.
2. Pericyclic Reactions - A Textbook: Reactions, Applications and Theory by S. Sankararaman, Roald Hoffmann
3. Orbital Symmetry: A problem solving approach- R. E. Lehr and A. P. Marchand
4. Pericyclic Reactions by A Mechanistic and Problem-Solving Approach by Sunil Kumar Vinod Kumar S.P. Singh
5. Pericyclic Reactions- S. Sankararaman, A text Book, Wiley VCH, 2005
6. Organic Chemistry- Clayden, Greeves, Warren and Wothers, Oxford University press, 2001.
7. Organic chemistry by Jonathan Clayden (2nd edition)
8. Photochemistry and Pericyclic reactions by Jagdamba Singh and Jaya singh.
9. Pericyclic Reactions by S.M. Mukherji.
10. Chem. Commun., 2007, 2211–2221 (10.1039/b700054p)
11. K.I. Ramachandran, G. Deepa, K. Namboori, Computational Chemistry and Molecular Modeling: Principles and Applications, Springer, 2008
12. F. Jensen. Introduction to Computational Chemistry (Second Edition, Wiley), 2007
13. Advanced Organic Chemistry, Part A by F. A. Carey and R. J. Sundberg
14. Excited states in Organic Chemistry by J.A. Barltrop and J.D.Coyle
15. Organic photochemistry: A visual approach by Jan Kopecky

Course/ Paper Title	**Protection-Deprotection and Carbohydrate Chemistry**
Course Code	21SMOC234A
Semester	III
No. of Credits	2 Credits (24 L, 06T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	Concept of Protection and de-protection groups and its application in organic synthesis
2.	Concept of chiral templates and use of chiral canters for synthesis natural molecules
3.	Basic interconversion of sugar molecules in different forms
4.	Donor and Acceptor concept in glycosylation
5.	Arming, and disarming groups concept and effect of protective group in glycosylation reaction
6.	Various Glycosyl donors and their activation

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Know and apply the protective groups during organic synthesis that include Protection and deprotection mechanism.
2.	Identify different forms sugar molecules
3.	Understand the formation of Gycosidic bonds using Donor and Acceptor in glycosylation

4.	Understand the Arming, and disarming groups and their role in glycosylation reaction
5.	Identify different Glycosyl donors and their activation.

Syllabus for Protection-Deprotection and Carbohydrate Chemistry [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	Protection and de-protection of functional group in organic synthesis: **Hydroxyl group-** alkyl ether, benzyl ether, acyl, PMB, Trityl, TMS, TBDMS, THP, MOM, MEM, MIP ether; Diol - Acetone, Cyclohexanone; **Amines-** Benzyl, Acyl, CBZ, BOC, FMOC, **Carboxyl group-**Ester, DCCI, DIPCDI; **Ketone and aldehydes-** Glycol, Thioglycol, Ketal, Acetal; Orthoesters as protecting groups, Protection de-protection approach - In Solid phase synthesis of polypeptide; polynucleotide, cyclitols, and amino-sugars.	**07**
II	**Basics of Carbohydrates:** Introduction of sugars, structures of monosaccharides, triose, tetrose, pentose, hexose, D/L forms of aldoses and ketoses in Fisher projections, cyclic hemiacetal forms of monosaccharides, representation of monosaccharide structure (Fisher, Zig-zag, Mills, Haworth projection and Chair conformation), The structure of Glucose, the anomeric configuration, mutarotation (D-Glucose), Conformations of monosaccharides, the anomeric effect. Modified monosaccharides, Alditols, Cyclitols, Nomenclature of monosaccharides, Cyclic forms of the α and β-D-aldoses.	**04**
III	Glycosyl donor and acceptor concept, their role in glycosylation Effect of protecting groups on glycosylation stereoselectivity and coupling efficiency, Arming, and disarming groups concept. General methods and stereochemical aspect of glycosyl bond formation	**07**

IV	Synthesis of glycosyl donor such as; Halides, Trichloroacetimides, Glycals and Glycal derivatives, Thioglycosides, Phosphites, n-Pentyl glycosides, Sulfoxides Diazarines and their glycosylation reaction, Alkylation of reducing sugars. Mannosides, Synthesis of 2-Deoxy Sugars, Orthogonal strategy in Oligosaccharide synthesis. Intramolecular glycosylation	**06**

Reference Books: -

1. Greene's protective groups in organic synthesis –Wuts and 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)

5. Chiron Approach in organic synthesis – S. Hanessianh

6. Organic Chemistry – R. P. Morrison and R. N. Boyd

7. Organic Chemistry – I. L. Finar, volume II.

8. Essentials of Carbohydrate Chemistry and Biology: T. K. Lindhorst, WILEY-VCH, 2000, Chapter 3.

9. Monosaccharide's: Their Chemistry and their Roles in Natural Products: Peter M. Collins, Robert J. Ferrier: John Wiley & Sons, 1995.

10. Carbohydrate in Chemistry and Biology: Part 1 Chemistry of Saccharides Vol.1. WILEY-VCH, 2000.

11. The Organic Chemistry of Sugars; By: Daniel E. Levy Peter Fugedi, Publication: Taylor & Francis, Published on 2006

12. Handbook of Chemical Glycosylation by Alexei V. Demchenko, Wiley VCH, 2008

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Course/ Paper Title	**Bio-Organic Chemistry**
Course Code	21SMOC234B
Semester	III
No. of Credits	2 Credits, (24 L, 06T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The students should be able to understand bioorganic molecules
2.	The students should be able to learn; structure and reactivity of biological molecules such as peptides, carbohydrates, lipids and nucleic acids
3.	Basic mechanism of biomolecules

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Classify bio-organic molecules.
2.	The students should be able to comprehend; structure and reactivity of biological molecules
3.	The students should be able to understand basic action of biomolecules.

Syllabus for Bio-Organic Chemistry [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Introduction to Bio-organic Chemistry**: Overview of Bio-organic Chemistry- Historical Connection Between Organic and Biological Chemistry; Weak Interactions in Organic and Biological World; Proximity Effect in Organic Chemistry; Molecular Recognition; Chemistry of the Living Cells; Analogy Between Biochemical and Organic Reaction.	**04**
II	**Bioorganic Chemistry of Amino Acids**: Introduction-Overview of Chemical Biology; Amino Acids and their Asymmetric Synthesis; Chemistry of Peptide Bonds; Peptide Secondary Structures and Tools for Stabilization; Natural α-amino Acids and β-peptides; β-Turn Peptidomimetics; β-lactam based peptidomimetics	**06**
III	**Bioorganic Chemistry of Enzymes:** Introduction to Enzyme Catalysis and Kinetics; The Catalytic Triad; Enzyme Inhibition and Drug design; Enzyme in Organic Chemistry; Antibody Catalysed Organic Reaction; Enzyme Models: Biomimetic Polyene Cyclisation; Squalene Biosynthesis.	**06**
IV	**Bio-organic Chemistry of Nucleic Acids:** History, Sugars and bases; Conformation of sugar-phosphate backbone; hydrogen bonding by bases; the double helix; A, B, and Z double helices; Stability of Double Helix; DNA intercalators; Chemical synthesis of DNA; Catalytic RNA, siRNA.	**06**

Reference Books:

1. Hermann Dugas: Bioorganic Chemistry-A chemicalApproach to Enzyme Action; 3rd Edition.

2. The organic chemistry of enzyme-catalyzed reactions, by Richard B.Silverman, Academic Press, San Diego, 2000, 717 pp.

3. Amino acids, peptides and proteins, by J.S. Davies, Royal Society of Chemistry, UK, Vol.35, 2006.

4. Biochemistry, 5th Ed. by Lubert Stryer, Jeremy M.Berg, and John L. Tymoczko.

5. Page, M. I. In The Chemistry of β-Lactams; Page, M. I.Ed.; Chapman Hall 1992, p. 79.

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Course/ Paper Title	**Practical: Ternary Mixture Separation**
Course Code	21SMOC235
Semester	III
No. of Credits	2 Credits, (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The application of theoretical principles and experimental
2.	To understand analysis of ternary mixtures of organic compound by using Ether separation method.
3.	To identify the type of compound with different nature
4.	Learn about Element present in the given compound and how to confirm functional groups

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Separate ternary mixture and can analyze each component of the mixture.
2.	They can use this knowledge to identify the unknown compound.

Syllabus for CHO-235: Practical: Ternary Mixture Separation [48 L + 12 T]

Unit No.	Title with Contents	Practical Sessions
I	Separation of minimum 06 mixtures containing three components with analysis. The mixtures should also involve separation of nitro phenols, amino acids, low boiling and water soluble and insoluble compounds solids and liquids with multifunctional groups. The mixture separation should be carried out on micro-scale using ether or water. The students should be able to 1. Understand and employ concept of type determination, separation 2. Meticulously record physical constants 3. Perform micro scale chemical elemental analysis 4. Perform qualitative estimation of functional groups 5. Recrystallize /distill the separated compounds 6. Extend these skills to organic synthesis	**12**

Reference Books:

1. Comprehensive Practical Organic Chemistry Qualitative Analysis by V.K. Ahluwalia, S. Dhingra.

2. Qualitative Organic Analysis By B. Haynes

3. Comprehensive Organic Chemistry Experiments for the Laboratory Classroom. (2020). United Kingdom: Royal Society of Chemistry.

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Course/ Paper Title	**Practical: Solvent Free Synthesis**
Course Code	21SMOC236
Semester	III
No. of Credits	2 Credits, (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	**Objectives**
Student should understand and learn;	
1.	To synthesize different reactions without Solvent.
2.	To learn the formation of C-C, C-N, C-X and N-N Bonds
3.	To apply how to evaluate a reaction or process and determine "Solvent Free" alternatives.
4.	To focus on the routes to improve industrial processes and to produce important products.
5.	To evaluate the synthetic pathway to produce pharmacological compounds.

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
Student should be able to;	
1.	Designed of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.
2.	Created awareness for reducing waste, minimizing energy consumption in

	organic synthesis.
3.	Understand the various synthetic pathways and implement it in the production of pharmacological compounds.
4.	Evaluate the concept of microwaves and ionic liquids in various chemical reactions

Syllabus for Practical: Solvent Free Synthesis and Phase transfer synthesis [48 L + 12 T]

Unit No.	Title with Contents	Practical Sessions
I	**Solvent Free Synthesis - Any Total 12 practical to be conducted from following;** The students should perform any 12 Syntheses from the following list. Students should acquire pre-experiment (Reading MSDS, purification of reactants and reagents, mechanism, stoichiometry etc) and post-experiment skills (work-up, isolation and purification of products, physical constants characterization using any spectroscopic methods etc.) A) Solvent Free Carbon–Carbon Bond Formation 1. Pinacol coupling reaction (Page 36) 2. Reformatsky reaction/Luche reaction (Page 36) 3. Knoevenagel condensation (Page 40) 4. Dieckmann condensation (Page 42) 5. 6. 7. 3-(ethoxycarbonyl)-4-hydroxy-5-(1-hydroxyalkyl)-2-isoxazoline-2-oxide (Page 46) 6. Biginelli reaction (Page 46) 9. Claisen reaction (Page 47) 10. Pechmann reaction (Page 50) B) Solvent-Free C–N Bond Formation 1. Azomethine synthesis (Page 213) 2. Diazepinone synthesis (Page 218)	**12**

	3. dibenzyl sulfone Synthesis (Page 297) C) Solvent-Free C–X Bond Formation 1. Cinnamic acid/ stilbene halogenations (Page 319) 2. Phenol bromination using, N-bromosuccinimide (Page 320) D) Solvent-Free N–N Bond Formation 1. Triazenes Synthesis (Page 335) 2. Beckmann rearrangement (Page 346) E) Spectral analysis of any one of the above synthesized compound	

Reference Books:

1. Solvent-free Organic Synthesis by Koichi Tanaka (Copyright © 2009 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 978-3-527-32264-)

2. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Agarwal.

3. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST

4. Additional Study Material: https://nptel.ac.in/courses/104/106/104106108/

Course/ Paper Title	**Practical: Double Stage Preparations**
Course Code	21SMOC237
Semester	III
No. of Credits	2 Credits, (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
	Student should understand and learn;
1.	The course aims is not only the continuation study of basic principles of organic chemistry, but it will also provide the important topics in Organic chemistry functional groups including (aromatic compounds, phenols, carboxylic acids and its derivatives, aldehydes & ketones, amines, and malonic ester synthesis).
2.	This helps students to gain experience to predict the functional group transformations, simple reaction mechanisms, and the synthesis of organic molecules by multi-step synthesis strategies.
3.	In addition of that, the course will also help students to understand the reaction mechanism subjects in later stages of their study.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Student should be able to;
1.	Acquire skills to observe and record scientific experiments.
2.	Students able to familiarize their self with the laboratory equipments,

	various chemicals, and set up chemical reactions to ensure safe and diligent laboratory practice.

Syllabus for Practical: Double Stage Preparations [48 L + 12 T]

Unit No.	Title with Contents	Practical Sessions
I	**Double stages preparation (Any Six Experiments)** At least **six** two stage heterocyclic preparations from the following should be carried out. The preparations should be carried out on micro scale 1. Benzaldehyde ------- Benzalacetophenone --------- Epoxide 2. 4-Nitro toluene ------- 4-nitro benzoic acid ------- 4-Amino benzoic acid 3. Resorcinol ------- 4-methyl-7-hydroxy coumarin ------- 4-Methyl-7-acetoxy coumarin 4. Cyclohexanone ------- Phenyl hydrazine ------- 1, 2, 3, 4-tetrahydrocarbazole 5. Hydroquinone ------- Hydroquinone diacetate ------- 1, 2, 4-Triacetoxy benzene 6. Acetanilide ------- p-Acetamidobenzene sulphonyl chloride -------- p-acetamidobenzene sulphonamide 7. Cyclohexanol from cyclohexanone (LAH reduction) 8. p-Cresol------- p-Cresyl benzoate ------- 2-Hydroxy-5-methyl benzophenone 9. Phthalimide ------ N-benzylphthalimide Benzylamine 10. Grignard Reaction 11. Phthalic acid ------- Phthalimide-------- Anthranilic acid 12. Benzyl cyanide------- p-Nitrobenzyl cyanide -------- p-Nitro phenyl acetic acid 13. Hydroquinone -------- Hydroquinone diacetate ------ 2, 5-dihydroxy	**12**

	acetopheneone 14. Benzoin ------ Desylbenzoate -------- 2, 4, 5-triphenyl Oxazole 15. Phenylacetate -------- O-Hydroxyacetophenone -------- Chromone -2-carboxylic acid 16. Benzaldehyde ------- Hippuric acid --------- Azalactone 17. Spectral analysis of any one of the above synthesized compound	

Reference Books:

1. Practical Organic Chemistry A. I. Vogel (Longmans).
2. Text Book of practical organic Chemistry F. G. Mann & B.C. Sanders.

SEMESTER-IV

Course/ Paper Title	**Retrosynthesis, Total Synthesis and Biogenesis of Natural Products**
Course Code	21SMOC241
Semester	IV
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	**Objectives**
Student should understand and learn;	
1.	Conceptualize retrosynthesis of one or more than one functional group with respect to disconnection approach.
2.	Independently design synthetic routes for the target molecules and understand synthetic strategies used by renowned research groups.
3.	Solve problems based on retrosynthetic perspectives.
4.	Identify the role and use of various reagents in asymmetric synthesis, stereochemistry of some important naturally occurring molecules and evaluate correct structure and stereochemistry.
5.	Understand the role of main building blocks in biosynthesis of natural products along with the basic construction mechanisms.
6.	Develop understanding of mechanistic details in the biosynthetic routes covered in the syllabus.

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
Student should be able to;	

1.	Understand conversion of one functional group to another and also functional group additions to enable viable disconnections
2.	Apply a range of standard functional group interconversions and to change the position of a functional group.
3.	Use disconnections to design effective organic synthesis of molecules using a range of known reaction types.
4.	To make big molecules from small molecules with specific stereochemistry
5.	Logical problem-solving approach.
6.	Synthetic methods to design new synthetic strategies.
7.	Retrosynthesis and synthesis of natural products.
8.	Explain the broad features of the sequences and able to predict how and why intermediates get transformed during the biosynthesis of natural products.

Section-I: Retrosynthesis and Total Synthesis [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Concepts of Retrosynthesis** Retrosynthetic analysis, disconnection approach, Synthons, multiple step synthesis, functional group interconversion, Illogical two group interconversion, C-C disconnection, Donor and acceptor Synthons, two group disconnection, 1,5 related functional group disconnection, Umpolung, convergent synthesis, special methods for small rings, Heteroatom and Heterocyclic compounds, problems	**10**
II	**Application of Retrosynthetic Approach** Retrosynthesis and synthesis of following Molecules: Juvabione, Longifolene (by E.J. Corey and Co-worker), Subincanadine E.	**04**
III	**Total Synthesis and stereochemistry determination of Pinnaic acid**	**10**

Reference Books:

1. Designing Organic Syntheses by Stuart Warren

2. Organic Chemistry from Retrosynthesis to Asymmetric Synthesis, by Vitomir Sunjic, Springer; 1st ed. 2016 edition
3. Classics in Total Synthesis by K.C. Nicolaou and E.J. Sorensen
4. Angew. Chem. Int. Ed. 2001, 40 (23), 4450-4452.
5. Angew. Chem. Int. Ed. 2001, 40, (23), 4453-4456.
6. Angew. Chem. Int. Ed. 2007, 46, 5746–5749
7. J. Org. Chem. 2017, 82, 11126- 11133
8. Advanced Organic Chemistry Carey, Sundberg; Part B

Section-II: Biogenesis of Natural Products [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Terpenoids** – Mono, Sesqui, Di and Triterpenoids and cholesterol	**12**
II	Alkaloids derived from ornithine, lysine, nicotinic acid, tyrosine and tryptophan.	**06**
III	**The shikimate pathway** – cinnamic acids, lignans and lignin, coumarins, flavonoids stilbenes and isoflavonoids	**06**

Reference Books:

1. Natural Product Biosynthesis: Chemical Logic and Enzymatic Machinery by Christopher T Walsh, Yi Tang
2. From Biosynthesis to Total Synthesis: Strategies and Tactics for Natural Products- Editor Alexandros L. Zografo
3. Medicinal Natural Products: A Biosynthetic Approach, 3rd Edition By Paul M. Dewick

Course/ Paper Title	**Advanced Organic Synthesis**
Course Code	21SMOC242
Semester	IV
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	To learn how to design a new route for synthesis of various reactions.
2.	To familiarize students with different organometallic complex.
3.	Know about the role of various reagents in synthetic methods.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	Understand how to design a new route for synthesis of various reactions.
2.	Can know the role of different reagents in organic synthesis.
3.	Can learn about the Organo Metallic, Metathesis, Multi Component, Ring Formation Reactions, and Click Chemistry.

Section-I: Organo Metallic Chemistry [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Metals complexes in organic synthesis:** Introduction- oxidation states of transition metals, 16-18 rule, dissociation, association, insertion, oxidative addition, reductive elimination of transition metal. **OrganoPalladium in organic synthesis-** Heck arylation, allylic activation, carbonylation, wacker oxidation, Stille, Sonogashira, Fukuyama, Kumada, Hiyama, Negeshi, Tsuji Trost, Buchwald-Hartwig and Suzuki coupling reactions and their importance. **Organonickel-** coupling, carbonylation, Oligomerisation and Reppe reaction. **OrganoIron** - Noyori annulation, Collmann's reagent, and Eletrophilic reactions. **OrganoCobalt –** Oxo Process, Pausand Khand reaction, Volhardt's co-trimerisation reaction. **OrganoRuthenium and organoRhodium reagents**	**14**
II	**Use of Boron and Si in organic synthesis** OrganoBoron, OrganoSilicon reagents in organic synthesis.	**10**

Section-II: Metathesis, Multi Component And Other Reactions [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**C=C formation reactions:** Wittig, Horner-Wordworth-Emmons, Shapiro, Bamford Stevens, McMurry, Julia-Lythgoe and Peterson olefination reactions.	**06**
II	**Metathesis of NHC's** – Synthesis and reactivity, Grubbs catalysts, Olefin metathesis by I^{st} and II^{nd} generation catalyst, reaction mechanism and application in the synthesis of homo and heterocyclic compounds	**06**

III	**Multi-component reactions:** Ugi, Passerini, Biginelli and Mannich reactions	**04**
IV	**Ring formation reactions:** Pausan-Khand, Bergman and Nazerov cyclization, Click chemistry reaction	**04**
V	**Other important reactions:** Baylis Hilman, Eschenmoser-Tanabe fragmentation, Mitsunobu reaction.	**04**

Reference Books:

1. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis-An Introduction, W. H.Freeman and Company, 2006.
2. Francis A. Carey and Richard J. Sundberg, "Advanced Organic Chemistry - Part B: Reactions and Synthesis", 5th Edition, Springer, 2007.
3. "Organic Chemistry" Clayden, Greeves, Warren and Wothers, Oxford University press, 2001
4. E. J. Corey and X. M. Cheng, the Logics of Chemical Synthesis, Wiley, 1989.
5. J. H. Fuhrhop, G. Li, Organic Synthesis: Concepts and Methods, 3rd edition, VCH, 1994.
6. W. Carruthers, Some Methods of Organic Synthesis, Cambridge University Press.
7. H. O. House, Modern Synthetic Reactions, Benjamin-Cummings Publishing Co. 1972
8. "Organic Synthesis – state of the art 2003-2005". Douglas Taber.

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Course/ Paper Title	**Medicinal Chemistry**
Course Code	21SMOC243
Semester	IV
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The basic ideas of drug development and discovery.
2.	To educate students on many areas of novel drug development and discovery
3.	Drug interaction with biological target

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Do Drug screening, target identification
2.	lead discovery, optimization
3.	The molecular basis of drug design and drug action.

Section-I - [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	Introduction to Peptides and proteins, Proteins as biological catalyst Nucleic acids, Metabolism, Chemistry of cofactors/coenzymes, Chemistry of TPP, PLP, Folic Acid and other vitamins, Principle of drug design, Chemistry of diseases and Drug development, Proton pump inhibitors and Problem solving.	**08**
II	Peptides, sequencing and applications in therapeutics, Solution phase and solid phase peptide synthesis and Modern techniques for biomolecules and disease diagnosis.	**06**
III	**Introduction to Medicinal Chemistry** - History, drug targets, Drug discovery, design and development, Case Study: Design of Oxamniquine.	**04**
IV	**Pharmacokinetics and Pharmacodynamics of drug**: Drug absorption, distribution, metabolism, elimination and toxicity, drug metabolism, biotransformation, Drug receptor interactions, Hansch Equation and significance of terms involved in it.	**06**

Section-II- [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	Structure and activity Relationship: QSAR, Applications of SAR and QSAR in drug design, physio-chemical parameters lipophilicity, partition coefficient, electronic ionization constant, Case Study: Statins.	**10**
II	Introduction, Developments, SAR, Mode of action, limitations and adverse effect of Anti-infective Agents, Beta lactam antibacterial agents (Penicillins, Cephalosporins), Tetracyclins, Macrolides, Chloramphenicol, Polyenes, Amphotrecin-B, Azoles, Amantadine, Acyclovir, Quinine, Quinolines, Quinolones, Refamycine, Sulphonamides.	**14**

Reference Books:

1. Biochemistry, 5th Ed.(Hardcover) by Lubert Stryer, Jeremy M.Berg, and John L. Tymoczko.

2. Amino acids, peptides and proteins, by J.S. Davies, Royal Society of Chemistry, UK, Vol. 35, 2006.

3. Medicinal Chemistry and Drug Discovery by Burger.

4. Introduction to Medicinal Chemistry by Grham and Patrick.

5. Introduction to Drug Design by J. R. Dimmock and S.S. Pandeya.

6. The Organic Chemistry of Drug Design and Drug Action, 3rd Edition, R. B. Silverman, Academic Press, 2014.

7. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed Robert F Dorge, 12th Edition, 2010.

Course/ Paper Title	**Asymmetric Synthesis** **(Elective/Option Paper)**
Course Code	21SMOC244A
Semester	IV
No. of Credits	2 Credits (24 L, 06T)

Aims & Objectives of the Course

Sr. No.	**Objectives**
Student should understand and learn;	
1.	Student should understand and learn the concept of Asymmetric synthesis
2.	Discover reactions that will reliably provide optically pure compounds.
3.	Develop effective strategies for using chiral auxiliaries, catalysts, and the substrate to control stereochemical relationships.
4.	Be able to give a detailed account of the course and mechanism of illustrative examples of the following asymmetric reactions that utilize chiral auxiliaries: enolate alkylation (oxazolidinones, oxazolines and chiral hydrazones), asymmetric (Evans) Aldol reaction and cycloaddition.
5.	Be able to suggest the correct type of catalyst used for asymmetric reactions, the mechanism and applications of these reactions

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
Student should be able to;	
1.	Describe the asymmetric synthesis using the chiral auxiliary component.

2.	Explain industrial applications and importance of asymmetric reactions
3.	Able to understand enolate reaction in asymmetric synthesis
4.	Understand various aspects and definitions of asymmetric synthesis

Syllabus for CHO-244A: Asymmetric Synthesis [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	1. **Introduction of Asymmetric Synthesis:** Classification of Asymmetric reactions, Optical purity, ee and de, calculation of % ee and optical purity, Stereoselective Synthesis, Categories and Strategies in Asymmetric Synthesis: Chiral substrate controlled, Chiral auxiliary controlled, Chiral reagent controlled, Chiral catalyst controlled Asymmetric Synthesis. 2. **Chiral pool and Chiral auxiliaries:** chiral pool strategies in asymmetric synthesis, Chiral auxiliary- Evan's chiral Auxiliary, RAMP, SAMP, synthesis and Uses of Chiral Auxiliaries in asymmetric synthesis. 3. **Aldol reactions and related reactions-** Diastereoselective Aldol reaction, Aldol reaction of chiral enolate & achiral aldehydes, achiral enolate & chiral aldehydes, Heathcock aldol reaction, Double diastereoselective Aldol reaction, Chiral auxiliary-controlled Asymmetric Aldol reactions, Mukaiyama aldol reactions, Proline - catalyzed asymmetric Aldol reactions. 4. **Asymmetric Hydrogenation and Reduction**- catalytic hydrogenation using Rh, Ru metals, Use of Use of chiral BINOL, BINAP, Noyori asymmetric hydrogenation, CBS reduction. 5. **Asymmetric Epoxidation-** Sharpless Epoxidation, Jacobsen Epoxidation, Shi epoxidation, 6. **Asymmetric dihydroxylation** – phthalazine-based ligands DHQ and DHQD in hydroxylation, Aminohydroxylation 7. **Asymmetric Organocatalysis**- Enantioselective Organocatalysis	**24**

	Involving Iminium, Enamine. Proline and Macmillan Imidazolidinone catalyzed reactions, Organocascade Catalysis. asymmetric organocatalytic epoxidation.	

Reference Books:

1. ORGANIC CHEMISTRY by Jonathan Clayden (1st edition)
2. ORGANIC CHEMISTRY by Jonathan Clayden (2nd edition)
3. Modern Methods of Organic Synthesis by W. Carruthers
4. Advanced Organic Chemistry by Carey and Sundberg, Fifth Edition
5. Principles and Applications of Asymmetric Synthesis by Lin, Li, Chan. (2001 by John Wiley & Sons)
6. Catalytic Asymmetric Synthesis, by I. Ojima, John Wiley & Sons, New Jersey, 2010, 3rd Ed.
7. Catalysis in Asymmetric Synthesis by Vittorio Caprio and Jonathan M. J. Williams
8. Asymmetric synthesis by Garry Procter, Oxford Science
9. Asymmetric Synthesis by R.A. Aitken and S.N. Kilenyi
10. Modern Methods in Stereoselective Aldol Reactions by Rainer Mahrwald, Wiley-VCH
11. Selectivity in Organic Synthesis. Ward, R. S. (1999). United Kingdom: Wiley.
12. Angew. Chem. Int. Edn. 2008, 47, 4638–4660.
13. Stereochemistry of Organic compounds by Ernest L. Eliel, SAMUEL H. Willey (Ch.12)
14. Asymmetric Synthesis by Garry Procter

Course/ Paper Title	**Supramolecular reaction** **(Elective/Option Paper)**
Course Code	21SMOC244B
Semester	IV
No. of Credits	2 Credits (24 L, 06T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The concept of Covalent Organic Frameworks; It's Synthesis and Applications
2.	Idea of Organic Electroluminescent Materials
3.	The concept of Supramolecular Organic Compounds

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Understand chemistry of Covalent Organic Frameworks
2.	Comprehend function of Organic Electroluminescent Materials.
3.	Comprehend Host-Guest molecules their types and their applications

Syllabus for Supramolecular reaction [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Covalent Organic Frameworks: Structures, Synthesis,-** Ionothermal Synthesis, Microwave Synthesis, Mechanochemical Synthesis, Room-Temperature Synthesis and **Applications** – (Heterogeneous Catalytic Application of COFs Heterogeneous Catalysts of COFs for C–C Bond Coupling Reactions; Suzuki–Miyaura Reaction , Heck, Sonogashira, and Silane-Based Cross-Coupling Reactions, Chiral Heterogeneous Catalysts of COFs for Asymmetric C–C Bond Coupling Reactions, Heterogeneous Bimetallic or Bifunctional Catalysts of COFs.	**08**
II	**Organic Electroluminescent Materials:** Introduction to Electroluminescent (EL), Molecular organic electroluminescent materials, Charge injection and transport, Quantum efficiency, Reliability, OLED displays.	**06**
III	**Supramolecular Organic Compounds:** Overview of Supramolecular Chemistry, The Chemistry of Molecular Recognition – Host Molecules and Guest Molecules, (Crown Ethers, Cyclodextrin, Calixarene, etc), Supramolecular Topology (Carbon Nanotubes; Dendrimers, Rotaxanes)	**10**

Reference Books:

1. Review article by Maria S. Lohse and Thomas Bein Adv. Funct. Mater. 2018, 28(33), 1705553.

2. Review article by L.S. Hunga and C. H. Chen Materials Science and Engineering 2002, R 39, 143–222

3. Review by Matthew C. T. Fyfe and J. Fraser Stoddart Accounts of Chemical Research 1997, 30 (10), 393-401

4. Review article by Wei Chen and et al. Chem. Soc. Rev., 2015, 44, 2998-3022.

5. The Chemistry of Metal–Organic Frameworks- Wiley Online. Print ISBN: 9783527338740, Online ISBN:9783527693078, DOI:10.1002/9783527693078

6. Covalent Organic Frameworks - 1st Edition - Atsushi Nagai, ISBN 9789814800877, Published January 24, 2020 by Jenny Stanford Publishing.

7. Introduction to Supramolecular Chemistry- Kluwer Academic Publishers, Helena Dodziuk; Print ISBN: 1-4020-0214-9.

8. Supramolecular Chemistry-Fundamentals and Applications, Springer Publications, Katsuhiko Ariga ISBN-10 3-540-01298-2

Course/ Paper Title	**Practical: Convergent and Divergent Synthesis Practical**
Course Code	21SMOC245
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	**Objectives**
Student should understand and learn;	
1.	The course provides the important topics in Organic chemistry functional groups
2.	To predict the functional group transformations, simple reaction mechanisms, and the synthesis of organic molecules by multi-step synthesis strategies.
3.	In addition of that, the course will also help students to understand the TLC and physical parameter of compound.

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
Student should be able to;	
1.	Acquire skills to observe and record scientific experiments.
2.	Students able to familiarize their self with the laboratory equipments, various chemicals, and set up chemical reactions to ensure safe and diligent laboratory practice.

Syllabus for Practical: Convergent and Divergent Synthesis Practicals [48 L + 12 T]

Unit No.	Title with Contents
I	**Any two set from following** **SET-I** **A) Convergent Synthesis 1 (Three Stage Synthesis)** 1. Stage I: Anisole to 4-nitro anisole to 4-amino anisole (2 steps) 2. Stage II: Toluene to 4-nitro toluene to 3-acyl nitro toluene (2 steps) 3. Stage III: Synthesis of N-(1-(2-methyl-5-nitrophenyl) ethyl) aniline from 4-amino anisole, 3-acyl nitro toluene and SBH (One pot synthesis: MCR) **B) Divergent Synthesis 1 (3 Single Stage Synthesis from Acetyl acetone):** 1. Acetyl acetone to Pyrimidine 2. Acetyl acetone to 2,4-dimethyl-1H-benzo[b][1,4]diazepine 3. Acetyl acetone to Pyrazole 4. Acetyl acetone with 1mmol benzaldehyde to 3-benzylidenepentane-2,4-dione 5. Acetyl acetone with 3 mmol benzaldehyde into 3-benzylidene-6-phenylhex-5-ene-2,4-dione **SET-II** **A) Convergent Synthesis 2(Three Stage Synthesis)** 1. Stage I: 4-Nitro toluene to 4-amino toluene (Reduction by using Sn/HCl) 2. Stage II: Phenol into 2-hydroxy benzaldehyde (Reimer-Tiemann reaction) 3. Stage III: Synthesis of amidoalkyl-2-naphthols from β-Naphthol,4-amino toluene and of 2-hydroxy benzaldehyde (One pot synthesis: MCR) **B) Divergent Synthesis (3 Single Stage Synthesis from β-Naphthol)** 1. β-Naphthol to Synthetic dye (By diazonium coupling) 2. β-Naphthol to 6-Bromo-2-naphthol (Bromination reaction) 3. β-Naphthol to β-Naphthyl methyl ether (Methylation reaction) 4. β-Naphthol to temperature dependent sulfonation (Sulfonation reaction) 5. β-Naphthol to (β) Binol then Resolution of Binol (Resolution technique)

	SET-III **A) Convergent Synthesis-3 (Three Stage Synthesis)** 1. Stage I: Salicylic acid to 5-Chloro-2-hydroxybenzoic acid 2. Stage II: o- Anisidine to 2-methoxy-4-nitroaniline 3. Stage III: Synthesis of 5-chloro-2-hydroxy-N-(2-methoxy-4-nitrophenyl) benzamide from 5-Chloro-2-hydroxybenzoic acid, -methoxy-4-nitroaniline (One pot synthesis: MCR) **B) Divergent Synthesis-3 (3 Single Stage Synthesis from Salicylaldehyde)** 1. Salicylaldehyde to Salicylaldehyde phenylhydrazone 2. Salicylaldehyde with melanonitrile to 2-iminochromene by intramolecular cyclization. 3. Salicylaldehyde to 2-hydroxy-3, 5-dinitrobenzaldehyde **SET-IV** **A) Convergent Synthesis- 4** (Three Stage Synthesis) 1. Stage I: Benzene to actophenone (F.C acylation) 2. Stage II: 4-Nitrochlorobenzene into 4-amino chlorobenzene (Reduction by using hydrazine) 3. Stage III: Quinoline synthesis by using acetophenone, 4-amino chloro benzene and styrene (One pot synthesis: [3 + 2 + 1] cycloaddition reaction) **B) Divergent Synthesis-4** (5 Single Stage Synthesis from Acetophenone) 1. Acetophenone to Ethyl benzene by Wolf Kishner reduction 2. Acetophenone to m-Nitro acetophenone by nitration 3. Acetophenone to Chalcone using aromatic aldehyde 4. Acetophenone into Schiff base using aromatic amine 5. Acetophenone to Benzoic acid and Iodoform

Reference Books:

1. Practical physical chemistry, A. Findlay, T. A. Kitchner (Longmans, Green and Co.).
2. Experiments in Physical Chemistry, J.M. Wilson, K. J. Newcombe, A. R. Denko. R. M. W. Richett.
3. Senior Practical Physical Chemistry, B.D. Khosla and V. S. Garg (R. Chand and Co.,Delhi.).

4. Experimental Physical Chemistry, R C Das and B. Behera, Tata McGraw Hill, 1983.

5. Advanced Experimental Chemistry, Vol. I Physical by Gurtu & R. Kapoor, S Chand & Co.

6. Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T K Chondhekar, Anjali Publication.

Course/ Paper Title	**Practical: Carbohydrate synthesis and Isolation of Natural Compounds**
Course Code	21SMOC246
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	**Objectives**
Student should understand and learn;	
1.	During practical course students should able to synthesize different building blocks using various protecting group.
2.	Should learn the methods of isolation of natural compounds by using various techniques.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	To perform Isolation of pigments from different Flowers
2.	To perform Isolation of essential oils from natural sources
3.	To perform Isolation of medicinally important component from the natural products

Syllabus for Practical: Carbohydrate synthesis and Isolation of Natural Compounds [48 L + 12 T]

Unit No.	Title with Contents	Practical Sessions
I II III	**(Total 12 practical to be conducted)** **Carbohydrate Synthesis** 1) Synthesis and structural determination of α- and β-D-glucose penta- acetate. 2) Selective deacylation of α- and β-D-glucose penta-acetate. 3) Benzoylation of D-glucose.to D-glucose penta-benzoate. 4) Selective debenzoylation of D-glucose penta-benzoate 5) Synthesis 1, 2, 5,6-di-O-isopropylene-D-glucofuranose. 6) Synthesis of 1,2: 5,6 – di-O-isopropylene-3-O-benzyl –D-glucofuranose. **Unit II: Isolation of pigments from the natural products** 1. Orange Marigold 2. Rose 3. Sunflower 4. Hibiscus 5. Any coloured flowers/fruits available in the local area **(only one is allowed).** **Note:** Students should be able to collect reasonable quantities of colour pigments to do the characterization (Physical Constant, Elemental analysis functional group test etc) and should also form the appropriate derivative. They are encouraged to use these pigments for developing food grade natural colours from lesser known plant sources. **Unit III: Isolation of essential oils from the natural products** 1. Ginger	12

IV **V**	2. Lemongrass 3. Garlic 4. Ajwain /ajowan / Trachyspermum ammi 5. Vekhand (achourus calamus) root 6. Any natural products available in the local area **(only one is allowed)** **Note:** Students should be able to collect a reasonable quantities of essential oils to do the characterization(Physical Constant, Density, Elemental analysis functional group test) Should form the appropriate derivative. They are encouraged to use these essential oils for the development of the products like soap, perfumes etc. **Unit IV: Isolation of medicinally important component from the natural products** 1. Nimbin from Neem leave 2. Amyrin from Apati/Apta bark 3. Eujenol from Tulsi leaves 4. D-Galacturonic Acid from Jeshtamadh 5. Piper from Betel leaf **6.** Any medicinally important plants available in the local area **Unit V**. Spectral analysis of any one of the above synthesized/ isolated compounds	

Reference Books:

1. Essentials of Carbohydrate and Chemistry and Biology: Thisbe K. Lindhorst, WILEY-VCH, 2000.

2. Kawanata, K. P. R. Tretrahedron Lett. 1986, 27, 3415.

3. Bessodes, M., Shamszar, J. Antonakies, K., Synthesis, 1988, 560.

4. Vogel's Textbook of Organic Chemistry Practicals.

Course/ Paper Title	**Project/ industrial Training**
Course Code	21SMOC247A
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	**Objectives**
Student should understand and learn;	
1.	Students should carry out a small research project separately.
2.	This should make them familiar with i. Literature survey, research methodologies ii. Data Analysis iii. Column and TLC chromatographic techniques iv. Characterization of the products by analytical and spectral methods.

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
Student should be able to;	
1.	Understand the various synthetic pathways and implement it in the production of pharmacological compounds.
2.	Students will be able to interpret spectral data and other observations.

Details for Project [48 L + 12 T]

Unit No.	Title with Contents
I	**Project report must be written and submitted in a proper format as follows;** i. Certificate (Signed by Project guide and Head of the Department) ii. Certificates for Poster/Paper presented in conferences (if any) iii. Self-declaration certificate for plagiarism iv. Introduction (not more than 6 pages) v. Results and Discussions vi. Experimental Section vii. Conclusion viii. References (Use ACS format) ix. Spectroscopic or other relevant supporting data x. Acknowledgement 1. Interdisciplinary projects shall be encouraged; however, there **must be some chemistry component**. 2. Students should spend enough time for the project works (**more than** 4 hours per week for **15 weeks**) 3. At least 30% students should undertake projects/summer training/Internships etc. **4.** If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. **5. Systematic record of attendance of project students must be maintained by a mentor.** **6.** Project will be evaluated jointly by examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (15-20 min.) which will be followed by question-answer session (10 min). It is open type of examination.

Course/ Paper Title	**Practical: PTC/Microwave assisted Organic Synthesis and Instrumental Techniques**
Course Code	21SMOC247B
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	Maximize atom economy
2.	Use safer solvents and reaction conditions
3.	Analyze in real time to prevent pollution
4.	Introduction to modern Analytical Instrumentation techniques and their applications
5.	Use safer solvents and reaction conditions

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Understand advantages of Microwave assisted synthesis
2.	Importance of Phase Transfer Catalysis
3.	Use catalysts, not stoichiometric reagents.
4.	Use renewable feedstock
5.	Understand how to operate and importance of different modern

	Analytical instruments

Syllabus for Practical: PTC/Microwave assisted Organic Synthesis and Instrumental Techniques [48 L + 12 T]

Unit No.	Title with Contents	Practical Sessions
I	The organic synthesis using **PTC** of certain "Phase-Transfer Agents" (the PT catalysts) to facilitate the transport of one reagent from one phase into another (immiscible) phase wherein the other reagent exists. 1. TBAB-catalyzed synthesis of 2,4,5-triaryl imidazoles 2.TBAB-catalyzed synthesis of 1,3-dihydrobenzimidazol-2-ones under microwave-assisted 3. TBAB-catalyzed synthesis of 1,5-benzodiazepine derivatives in ethanol. 4. TBAB-catalyzed synthesis of aryl-14H-dibenzo[a,j]xanthenes under solvent-free 5. TBAB-catalyzed synthesis of 1,3-thiazine-4-yl-3,4-dihydropyrimidine-2(1H)-on 6.Tetrabutylammonium Hydrogen Sulfate Catalyzed Synthesis Of 3,4-Dihydropyrimidin-2(1H)-Ones Under Solvent-Free Conditions 7. TBAHS catalyzed Michael addition in water	**12**
II	**Instrumental Techniques:** The laboratory course is designed to complement the Principles of Analytical Instrumentation. This course will provide a practical introduction and experience in the use of modern analytical instrumentation. Students will face a number of real-world challenges and learn how to apply instrumental approaches to overcome them. Emphasis will be placed on sample preparation, instrumental operation/methods, and data interpretation for a range of pharmaceutical, biological, environmental, and industrial samples by using HPLC, Gas Chromatography, IR, UV Spectrophotometer, Microwave synthesizer.	

Reference Books:

1. Microwave-Assisted Organic Synthesis: A Green Chemical Approach. (2014). United States: Apple Academic Press.
2. Microwave Assisted Organic Synthesis. (2009). Germany: Wiley.
3. Ahmad Shaabani, Ayoob Bazgir & Sakineh Arab-Ameri (2004) Tetrabutylammonium hydrogen sulfate: an efficient catalyst for the synthesis of 3,4-dihydropyrimidin-2(1h)-ones under solvent-free conditions, Phosphorus, Sulfur, aJnd Silicon and the Related Elements, 179:11, 2169-2175, DOI: 10.1080/10426500490474815
4. Molecules 2020, 25, 5918; doi:10.3390/molecules25245918
5. J. Chem. Sci., Vol. 121, No. 1, January 2009, pp. 65–73

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