Mahatma Education Society's

Pillai HOC College of Arts, Science & Commerce (Autonomous) Rasayani

Affiliated to University of Mumbai
NAAC Accredited with "A+" Grade in cycle II
ISO 9001:2015 Certified

SYLLABUS

M.Sc. Organic Chemistry

As per National Education Policy 2020

Academic Year 2026-27

Sr. No	Name	Category	Signature
1	Dr. Dinesh Navale	Expert nominated by the Vice-Chancellor	
2	Ms. Komal Kamble	Subject experts from outside the parent University	
3	Dr. Anand K Singh	Subject experts from outside the parent University	Dr. Anand Singh
4	Dr. Bapu Gawade	Industry representative	
5	Mr. Rushikesh Ghodvinde	College Alumnus	Ghodvinde
6	Dr. Rinkoo Shantnu	Principal	
7	Mr. Binit Kumar	Vice principal	Mr. Binit Kumar
8	Dr. Richa Chauhan	Chairperson	
9	Ms. Remya MG	Member (Env. Sci.)	Remya
10	Dr. Archana Bhagwat	Member (Chemistry)	
11	Dr. Sulochana Bhalekar	Member (Chemistry)	
12	Dr. Vineetha P	Member (Physics)	
13	Ms. Komal Gunjal	Member (Chemistry)	
14	Ms. Shruti C. Hogale	Member (Physics)	Shrutiee
15	Ms. Juilee Shirke	Member (Physics)	

1. INTRODUCTION TO MASTER OF SCIENCE IN ORGANIC CHEMISTRY (M.Sc. OC)

The Master of Science in Organic Chemistry is a postgraduate programme that equips students with advanced insight into organic molecules—how they are structured, how they react, how they are synthesized, and how they are characterized and applied. It builds upon the knowledge gained during an undergraduate degree in Chemistry or a related field, and deepens the study of carbon-containing compounds and their transformations, using both theoretical concepts and practical laboratory techniques.

AIMS AND OBJECTIVES

The programme aims to enable students to:

Understand fundamental & advanced concepts in organic chemistry — reaction mechanisms, stereochemistry, functional groups, aromaticity, etc.
Develop laboratory skills for synthesis, purification, analysis, and structural elucidation of organic compounds using modern instrumental techniques.
Gain experience in research and innovation via projects/thesis work, enabling them to design experiments, solve problems, and communicate results.
Learn specialized and emerging topics, such as green chemistry, natural products, heterocyclic compounds, organometallic chemistry, computational tools, etc.
Prepare for careers in academia, industry, or research — whether in pharmaceutical and chemical companies, government labs, quality control/assurance, teaching, or further higher studies.

Programme Outcomes (POs)

Sr. No	PO Title	POs in brief
PO 1	Fundamental Knowledge Acquisition	Graduates will demonstrate a comprehensive and foundational knowledge of their chosen discipline along with an awareness of interdisciplinary connections.
PO 2	Critical Thinking and Analytical Reasoning	Graduates will be able to analyse complex problems, synthesize data from multiple sources (qualitative and quantitative), and employ logical reasoning to formulate well-supported conclusions and arguments.
PO 3	Effective Communication	Graduates will exhibit proficiency in both written and oral communication, articulating ideas clearly, persuasively, and ethically to diverse audiences
PO 4	Problem Solving	Graduates will possess the ability to identify, formulate, and design solutions for real-world problems in their professional or social contexts, applying relevant theoretical knowledge and practical skills.
PO 5	Informatio n and Digital Literacy	Graduates will demonstrate the capability to locate, evaluate, and effectively use information from various sources, and utilize modern tools and Information and Communication Technology (ICT) for professional and academic tasks.
PO 6	Research Skills and Scientific Temperam ent	Graduates will develop a sense of inquiry and research methodology, including the ability to design experiments (where applicable), collect and analyse data, and interpret results while maintaining scientific rigor and intellectual honesty.
PO 7	Ethical Reasoning and Professional Integrity	Graduates will recognize ethical dilemmas, commit to professional and academic ethics, and demonstrate an understanding of moral and social responsibilities in their personal and professional conduct.
PO8	Employability and Professional Skills	Graduates will acquire the necessary job-ready skills, managerial competencies, and professional values to secure gainful employment or pursue advanced education in their respective fields.
PO 9	Environmental and Sustainability Consciousness	Graduates will understand the importance of environmental conservation and sustainable development, displaying responsibility toward ecological challenges and advocating for healthy environmental practices.
PO 10	Life-Long Learning	Graduates will develop the capacity for independent and self-directed learning to continuously upgrade their knowledge and skills, enabling them to adapt to rapid technological and societal changes.

PO 11	Civic and Social Responsibility	Graduates will act as responsible citizens with an informed awareness of constitutional values, engaging proactively in community development and addressing social needs.
PO 12	Empathy and Social Intelligence	Graduates will be able to cultivate and demonstrate affective, interpersonal, social and emotional intelligence.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO's No.	PSO's in Brief
PSO1	Gain knowledge of the advanced concepts in the branch of chemistry, scrutinize and accomplish a solution to problems encountered in the field of research and analysis.
PSO2	Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.
PSO3	Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analyzed using practical skills inculcated in them during the course.
PSO4	Design, analysis, synthesis and interpretation data to provide solutions to different industrial problems by working in the multi-disciplinary areas of chemical sciences.

Evaluation Pattern

Marking Code	Marking Scheme
A	50 Marks Semester End Exam, 50 Marks Continuous Assessment (distributed within 20 Marks Class Test, 20 Marks Research paper & Presentation and 10 Marks Assignment)
B	100 Marks research Project/OJT Examination (50 Marks Semester End Viva Exam, 50 Marks Continuous Assessment)
C	150 Marks Research Project Assessment (75 Marks Semester End Viva Exam, 75 Marks Continuous Assessment)
D	50 Marks of Continuous Assessment (20 Marks Class Test, 20 Marks Research paper & Presentation and 10 Marks Assignment)
E	100/50 Marks Practical Examination (distributed within 40 Marks Practical Module, 05 Marks Journal, 05 Marks Viva)

Course Structure

Semester III							
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures/ Week**	**Evaluation Pattern**
HPSCY201	Major	Organic Reaction Mechanism	Theory	100	4	4	A
HPSCY202	Major	Pericyclic Reactions & Photochemistry	Theory	100	4	4	A
HPSCY203	Major	Stereochemistry & Advanced Spectroscopy	Theory	100	4	4	A
HPSCY204	Elective	Asymmetric Synthesis and Green Chemistry	Theory	50	2	2	D
HPSCY205P	Major-Practical	Combined Spectral Analysis	Practical	50	2	4	E
HPSCY206P	Elective Practical	Green Chemistry Practical	Practical	50	2	4	E
HPSCY207	Major	Research Project	Research Project	100	4	8	B
Total				550	22		**

Semester IV							
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures / Week**	**Evaluation Pattern**
HPSCY251	Major	Synthetic Organic Chemistry	Theory	100	4	4	A
HPSCY252	Major	Chemistry of Natural Products	Theory	100	4	4	A
HPSCY253	Major	Metals/Non- metals in Organic synthesis & Heterocyclic Chemistry	Theory	100	4	4	A
HPSCY254P	Major-Practical	Ternary Mixture Separation	Practical	100	4	8	E
HPSCY255	Major	Research Project	Research Project	150	6	8	C
Total				550	22		**

Semester III

<table>
<tr><td>BOS</td><td colspan="6">Natural and Physical Sciences</td></tr>
<tr><td>Course</td><td colspan="6">ORGANIC REACTION MECHANISM</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">HPSCY201</td><td>Level</td><td colspan="4">6.5</td></tr>
<tr><td>Type</td><td>Theory</td><td>Practical</td><td colspan="2">Total</td></tr>
<tr><td>Semester</td><td>III</td><td>Credits</td><td>4</td><td>-</td><td colspan="2">4</td></tr>
<tr><td>Type</td><td>Major: Mandatory</td><td>No. of Teaching hours</td><td>60</td><td>-</td><td colspan="2">60</td></tr>
<tr><td rowspan="2">Evaluation Pattern</td><td>Total Marks</td><td>Semester End</td><td colspan="2">Continuous</td><td colspan="2">Practical</td></tr>
<tr><td>100</td><td>50</td><td colspan="2">50</td><td colspan="2">-</td></tr>
</table>

Learning Objectives	
1	Understand and describe the structure, generation, stability, and reactivity of key organic reactive intermediates
2	Analyze organic reaction mechanisms using Linear Free Energy Relationships (LFER)
3	Describe the mechanisms and application of key name reactions
4	Illustrate the formation and utility of enamines in organic synthesis.

Course Outcomes	
CO1	Apply advanced concepts of reactive intermediates and their chemistry to predict products and mechanisms of organic reactions.
CO2	Utilize LFER, Hammett, and Taft equations to quantitatively analyze reaction mechanisms and rationalize the influence of substituents and solvents
CO3	Understand and explain the mechanisms of key name reactions
CO4	Analyse the reactivity of enamines versus enolates and synthesize asymmetric reactions using chiral enamines.

Modules at Glance

Module No.	Content	No. of Hours	CO Mapping
I	Organic reactive intermediates and C-C bond formation reactions	15	CO1
II	Linear Free Energy Relationship (LFER)	15	CO2
III	Name reactions with mechanism and application	15	CO3
IV	Enamines, Ylides and α-C-H functionalization	15	CO4
		60	

Syllabus

Module No.	Content	No. of Hours
I	**Organic reactive intermediates** methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes. [8L] **Carbon–Carbon Bond-Forming Reactions** Mannich, Cannizzaro, Darzens, Dieckmann, Claisen Baylis-Hillman reactions, benzoin condensation, alkylation of enolates and stereochemistry thereof, Conjugate additions [7L]	15
II	**Linear Free Energy Relationship** Structural effects and reactivity: Linear free energy relationship (LFER) in determination of organic reaction mechanism [5L] **Hammett equation** 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.[10L]	15
III	**Name reactions with mechanism and application** Mukaiyama esterification, Mitsonobu reaction, Darzen's Glycidic Ester synthesis, Ritter reaction, Yamaguchi esterification, Peterson olefination. [5L] Domino reactions: Characteristics; Nazerov cyclization. [3L] Multicomponent reactions: Strecker reaction,Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis. [4L] Click Reactions: Characteristics; Huisgen 1,3-Dipolar Cycloaddition. [3L]	15

IV	**Enamines, Ylides and α-C-H functionalization** Enamines: Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction, Reactivity, comparison between enamines and enolates, Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines. [4L] **Ylides** Phosphorus, Sulfur and Nitrogen Ylides: Preparation and their synthetic applications along with their stereochemical aspects. Wittig reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination.6L **α-C-H functionalization:** By nitro, sulfoxide, sulfone and phosphonate group: Generation of carbanions by strong bases (LDA/n-butyl lithium) and applications in C-C bond formation Bamford-Stevens reaction, Julia olefination and its modification, Seyferth–Gilbert homologation, Steven's rearrangement. [5L]	15

Case study examples
A chemist wants to synthesize the following β-alkylated ketone from cyclohexanone: Target molecule: A β-methyl–β-phenyl substituted cyclohexanone. Case Details: Direct alkylation of cyclohexanone with base fails due to self-condensation. The chemist instead uses *pyrrolidine* as a secondary amine and *benzyl bromide* followed by *methyl iodide* as alkylating agents.
Design a route to convert the following aldehyde into an E-selective α,β-unsaturated ester: Substrate: p-Methoxybenzaldehyde Target: p-Methoxycinnamate ester (major E-alkene) You have the following reagents available: Triethyl phosphonoacetate n-BuLi $Ph_3P{=}CH_2$ DMSO, n-BuLi (for Julia olefination) Sulfone-stabilized carbanions LDA

- **References**

1. Reactive intermediate in organic chemistry: Structure, mechanism and reactions by Maya Shankar Singh. Publisher: Wiley VCH
2. Modern Organic Synthesis: An Introduction by Michael H. Nantz and George S. Zweifel. Publisher: Wiley 2006
3. Modern Physical Organic Chemistry by Eric V. Anslyn and Dennis A. Dougherty. 2004
4. Organic reactions and their mechanisms, 3rd revised edition, P.S. Kalsi, New Age International Publishers.
5. Name Reactions, Jie Jack Lie, 3rd Edn., Springer.

Semester End Evaluation (50 Marks) **Time: 2 Hrs**

Paper Pattern

Question No.	**Questions**	**Total Marks: 50**
Q1	Attempt any three out of five (05M) Module I 4Q, Module IV 1Q	15
Q2	Attempt any three out of five (05M) Module II 4Q, Module IV 1Q	15
Q3	Attempt any three out of five (05M) Module III 4Q, Module IV 1Q	15
Q4	Case study/application based question Module IV 1Q	05
	Total	*50*

Note:

Equal Weightage to be given to all the modules.

<table>
<tr><td>BOS</td><td colspan="5">Natural and Physical Sciences</td></tr>
<tr><td>Course</td><td colspan="5">PERICYCLIC REACTIONS AND PHOTOCHEMISTRY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">HPSCY202</td><td>Level</td><td colspan="3">6.5</td></tr>
<tr><td>Type</td><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Semester</td><td>III</td><td>Credits</td><td>4</td><td>-</td><td>4</td></tr>
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<tr><td>100</td><td>50</td><td>50</td><td colspan="2">-</td></tr>
</table>

Learning Objectives	
1	Classify pericyclic reactions and explain their principles using molecular orbital symmetry and Woodward-Hoffmann rules.
2	Predict stereochemical outcomes of electrocyclic, cycloaddition, and sigmatropic reactions using FMO and PMO approaches.
3	Describe key photochemical principles and mechanisms for carbonyls, olefins, and arenes.
4	Apply pericyclic and photochemical concepts to interpret selectivity and synthetic applications.

Course Outcomes	
CO1	Master pericyclic reaction mechanisms and rationalize them with orbital theory and Woodward-Hoffmann rules.
CO2	Analyze advanced cycloadditions, sigmatropic shifts, and electrocyclic reactions, including stereochemical effects.
CO3	Understand the fundamentals of photochemical processes.
CO4	Demonstrate proficiency in photochemical processes and transformations in organic molecules.

Modules at Glance

Module No.	Content	No. of Hours	Mapping with CO
I	Pericyclic Reactions: Classification, Symmetry, and Electrocyclic Mechanisms	15	CO1
II	Advanced Pericyclic Reactions	15	CO2
III	Fundamentals of Photochemistry	15	CO3
IV	Photochemistry of Organic Molecules	15	CO4

Syllabus

Module No.	Content	No. of Hours
I	**Pericyclic Reactions: Classification, Symmetry, and Electrocyclic Mechanisms** Classification of pericyclic reactions; thermal and photochemical reactions. Three approaches: Evidence for the concertedness of bond making and breaking. Symmetry-Allowed and Symmetry-Forbidden Reactions – The Woodward-Hoffmann Rules-Class by Class. The generalised Woodward-Hoffmann Rule. Explanations for Woodward- Hoffmann rules. The Aromatic Transition structures [Huckel and Mobius]. Frontier Orbitals Correlation Diagrams, FMO and PMO approach Molecular orbital symmetry, Frontier orbital of ethylene, 1, 3 butadiene, 1, 3, 5 hexatriene and allyl system. Electrocyclic reactions: Conrotatory and disrotatory motions, $4n\pi$ and $(4n+2)\ \pi$ electron and allyl systems.	15
II	**Advanced Pericyclic Reactions** Cycloaddition reactions: Supra and antarafacial additions, 4n and 4n+2 systems, 2+2 additions of ketenes. Diels-Alder reactions, 1, 3- Dipolar cycloaddition and cheletropic reactions, ene reaction, retro- Diels-Alder reaction, regioselectivity, periselectivity, torquoselectivity, site selectivity and effect of substituents in Diels- Alder reactions. Other Cycloaddition Reactions- [4+6] Cycloadditions, Ketene Cycloaddition, Allene Cycloadditions, Carbene Cycloaddition, Epoxidation and Related Cycloadditions. Other Pericyclic reactions: Sigmatropic rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations. Cope (including oxy Cope and aza-Cope) and Claisen rearrangements. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A.	15

III	**Fundamentals of Photochemistry** Principles of photochemistry: Electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process Photochemistry of carbonyl compounds:$\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transitions, distinctive features of Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction.	15
IV	**Photochemistry of Organic Compounds** Photochemistry of olefins: cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di- π- methane rearrangement including aza-di- π -methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation of alkenes. Photochemistry of arenes: 1, 2- , 1, 3- and 1, 4 additions. Photocycloadditions of aromatic Rings. Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions. Chemiluminescence, bioluminescence with 1-2 examples.	15

Case study examples

1. A chemist exposes cyclohexene to UV light (254 nm) in the presence of acetone as a sensitizer. The reaction mixture shows formation of two major products:

- Product A: A trans–cis rearranged isomer of cyclohexene
- Product B: A bicyclic cyclobutane-containing dimer

2.

- A solution of anthracene is irradiated with visible light in the presence of methylene blue and oxygen. Two products are observed:
- Product X: An anthracene endoperoxide
- Product Y: A small amount of 9,10-dihydroanthracene, formed via radical pathways.

- **References**

1. Photochemistry and Pericyclic reactions by Jagadamba singh and Maya singh. New Age International Publication.
2. Pericyclic reactions by Ian Fleming. Oxford University Press.

Semester End Evaluation (50 Marks) ***Time: 2 Hrs***

Paper Pattern

Question No.	**Questions**	**Total Marks: 50**
Q1	Attempt any three out of five (05M) Module I 4Q, Module IV 1Q	15
Q2	Attempt any three out of five (05M) Module II 4Q, Module IV 1Q	15
Q3	Attempt any three out of five (05M) Module III 4Q, Module IV 1Q	15
Q4	Case study/application based question Module IV 1Q	05
	Total	*50*

Note:

Equal Weightage to be given to all the modules.

BOS	**Natural and Physical Sciences**				
Course	**STEREOCHEMISTRY AND ADVANCED SPECTROSCOPY**				
Course Code	**HPSCY203**	**Level**	**6.5**		
		Type	**Theory**	**Practical**	**Total**
Semester	**III**	**Credits**	**4**	**-**	**4**
Type	**Major: Mandatory**	**No. of Teaching hours**	**60**	**-**	**60**

Evaluation Pattern	**Total Marks**	**Semester End**	**Continuous**	**Practical**
	100	**50**	**50**	**-**

<u>Learning Objectives</u>	
1	Classify molecules by point group symmetry, perform conformational analysis of medium rings, and evaluate the impact of conformation on reactivity and stereochemistry
2	Grasp the concepts of proton and 13C spectroscopy as well as advanced techniques.
3	Determine structure of molecules given their spectra
4	Determine structure of molecules given their spectra using advanced spectroscopic techniques.

<u>Course Outcomes</u>	
CO1	Demonstrate proficiency in the stereochemical analysis and nomenclature of complex ring systems, including perhydrophenanthrene, perhydroanthracene, hydrindane, steroids, and bridged/heterocyclic systems.
CO2	Employ modern methods for stereochemical determination, including NMR, and critically evaluate methods for resolution and assessment of optical purity.
CO3	Read and correlate aspects of spectral data to structures
CO4	Analyze different types of spectra and determine structures of molecules

Modules at Glance

Module No.	Content	No. of Hours	CO Mapping
I	Stereochemistry and symmetry	15	CO1
II	Stereochemistry of fused and bridged rings	15	CO2
III	Advanced spectroscopic techniques-I	15	CO3, CO4
IV	Advanced spectroscopic techniques-II	15	CO3, CO4
		60	

Syllabus

Module No.	Content	No. of Hours
I	**Stereochemistry and symmetry** Classification of point groups based on symmetry elements with examples Conformational analysis of medium rings: Eight to ten membered rings and their unusual properties, I-strain, transannular reactions.[7L] Anancomeric systems, Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones (with $LiAlH_4$, selectride and MPV reduction) and oxidation of cyclohexanols. [8L]	15
II	**Stereochemistry of fused and bridged rings** Nomenclature, synthesis, stereochemical aspects of perhydrophenanthrene, perhydroanthracene, hydrindane, steroids, bridged system (bi, tri and polycyclic system) including heteroatoms, Bredt‘s rule. [8L] Resolution by mechanical separation of crystals, resolution by formation of diastereomers, second order asymmetric transformation, resolution by equilibrium asymmetric transformation, biochemical asymmetric transformation, criteria of optical purity. [4L] Determination of stereochemistry organic compounds using NMR [3L]	15
III	**Advanced spectroscopic Techniques-I** Proton NMR spectroscopy: Recapitulation, chemical and magnetic equivalence of protons, First order and second order spectra, Spin system notations (A_2, AB, AX, AB_2, AX_2, AMX and A_2B_2-A_2X_2 spin systems with suitable examples). Long range coupling (Allylic coupling, ‗W‘ coupling and Coupling in aromatic and heteroaromatic systems), Temperature effects (7L) ^{13}C –NMR spectroscopy: Recapitulation, equivalent and non- equivalent carbons (examples of aliphatic and aromatic compounds), ^{13}C- chemical shifts, calculation of ^{13}C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to ^{19}F and ^{31}P. (4L) Spectral problems based on UV, IR, ^1HNMR and ^{13}CNMR and Mass spectroscopy (4L)	15

IV	**Advanced NMR techniques-II** 4.1: Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents, DEPT experiment, determining number of attached hydrogens (Methyl/methylene/methine and quaternary carbons), two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY techniques [8L] 4.2 Spectral problems based on UV, IR, 1HNMR, 13CNMR (Including 2D technique) and Mass spectroscopy [7L]	15

Case study examples
1. A compound with the molecular formula $C_6H_{12}O_2$ shows the following NMR characteristics: ^{13}C NMR (Broadband Decoupled) Signals at: 175, 68, 34, 29, 24, and 22 ppm (6 carbons total) DEPT-90 and DEPT-135 Results ● DEPT-90: signals at 68 and 34 ppm ● DEPT-135: ○ Positive: 68, 34, 29 ppm ○ Negative: 24 and 22 ppm ● Absent in DEPT: 175 ppm COSY Spectrum ● A strong cross-peak between protons of the carbons at 34 and 29 ppm ● Another cross-peak between 29 and 24 ppm signals
2. A compound isolated from a natural product extract has the formula $C_9H_{10}O_2$. Spectroscopic data: IR Spectrum ● Strong band at 1715 cm^{-1} ● Aromatic C–H stretches at ~3050 cm^{-1}

	Weak band near 1650 cm^{-1}
^{1}H NMR	
	Multiplet at 7.2–7.4 ppm (5H) Singlet at 3.85 ppm (3H) Singlet at 2.55 ppm (2H)
^{13}C NMR + HETCOR	
	167 ppm (quaternary carbon) — correlates with no proton 133, 129, 128 ppm — correlate with aromatic protons 55 ppm — correlates with 3.85 ppm singlet 30 ppm — correlates with 2.55 ppm singlet
Mass Spectrum	
	M^{+} peak at 150 Strong fragment at 121

- **References**

1. Organic Chemistry, Clayden Greeves Warren and Wothers Oxford Press (2001).
2. Stereochemistry of organic compounds: Principles and application by D. Nasipuri. New Age International (P) LTD.
3. Introduction to spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, 4th ed., 2009.
4. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991
5. Spectroscopy of Organic compounds, P.S. Kalsi, New Age International Pub. Ltd. And Wiley Eastern Ltd., Second edition, 1995

Semester End Evaluation (50 Marks)
Paper Pattern

Time: 2 Hr.

Question No.	**Questions**	**Total Marks: 50**
Q1	Attempt any three out of five (05M) Module I 4Q, Module IV 1Q	15
Q2	Attempt any three out of five (05M) Module II 4Q, Module IV 1Q	15
Q3	Attempt any three out of five (05M) Module III 4Q, Module IV 1Q	15
Q4	Case study/application based question Module IV 1Q	05
	Total	*50*

Note:
Equal Weightage to be given to all the modules.

BOS	**Natural and Physical Sciences**					
Course	**ASYMMETRIC SYNTHESIS AND GREEN CHEMISTRY**					
Course Code	**HPSCY204**	**Level**	**6.5**			
		Type	**Theory**	**Practical**	**Total**	
Semester	**III**	**Credits**	2	-	2	
Type	**Elective**	**No. of Teaching hours**	**30**	**-**	**30**	
Evaluation Pattern	**Total Marks**	**Semester End**	**Continuous**	**Practical**		
	50	**NA**	**50**	**-**		

Learning Objectives	
1	Carry out various asymmetric transformations and employ such reactions in asymmetric organic synthesis of important chiral molecules.
2	Students will be able to explain the 12 principles of green chemistry and apply them to design environmentally friendly chemical syntheses
3	Students will compare traditional and green synthetic routes for industrially important compounds

Course Outcomes	
CO1	Predict the stereochemical outcome under the conditions of asymmetric synthesis and to apply asymmetric transformations in a logical manner for the synthesis of chiral molecules.
CO2	Analyze and implement green reagents, catalysts and solvents in organic synthesis, justifying their environmental and practical advantages
CO3	Assess the role of advanced green catalysts, types, advantages and disadvantages and propose suitable catalytic systems for sustainable chemical processes

Modules at Glance

Module No.	Content	No. of Hours	CO Mapping
I	Asymmetric Synthesis	15	CO1
II	Green Chemistry	15	CO2, CO3
		30	

Syllabus

Module No.	Content	No. of Lectures
I	**Asymmetric synthesis** Principles of asymmetric synthesis: Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions. (3L) Synthesis of L-DOPA [Knowles's Mosanto process]. Asymmetric reactions with mechanism: Aldol and related reactions, Cram's rule, Felkin-Anh model, Sharpless enantioselective epoxidation, hydroxylation, aminohydroxylation, Diels-Alder reaction, reduction of prochiral carbonyl compounds and olefins. (9L) Use of chiral auxiliaries in diastereoselective reductions, asymmetric amplification. Use of chiral BINOLs, BINAPs and chiral oxazolines asymmetric transformations. (3L)	15
II	**Green Chemistry** Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts (1L). Use of the following in green synthesis with suitable examples: a) Green reagents: dimethyl carbonate, polymer supported reagents. b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyl trimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts. c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide. d) Solid state reactions: solid phase synthesis, solid supported synthesis e) Microwave assisted synthesis: reactions in water, reactions in organic solvents, solvent free reactions. f) Ultrasound assisted reactions (9L). Comparison of traditional processes versus green processes in the syntheses of ibuprofen, adipic acid, 4-aminodiphenylamine, p- bromotoluene and benzimidazole (3L). Green Catalysts: Nanocatalyst, Types of nanocatalysts, Advantages and Disadvantages of Nanocatalysts, Idea of Magnetically separable nanocatalysts (2L).	15

Case study examples
1. A pharmaceutical company wants to replace its traditional esterification method (carboxylic acid + alcohol + conc. H_2SO_4, reflux for 12 hours, large aqueous waste) with a greener process. Question: Design a greener synthetic route for making ethyl benzoate, focusing on: 1. Choice of green reagent (e.g., DMC) and why it is safer/cleaner than concentrated mineral acids. 2. A green solvent or solvent-free condition suitable for scale-up. 3. A green catalyst (solid or recyclable) that minimizes waste. 4. How microwave heating or phase-transfer catalysis could further reduce reaction time and energy use. Briefly justify each choice using at least two principles of green chemistry.
2. A fine-chemicals plant is evaluating whether to upgrade from the Boot Process (traditional synthesis of ibuprofen, 6 steps, large waste streams) to a greener BHC Process (3 steps, catalytic, atom-efficient). Question: Compare the traditional and green processes by briefly discussing: 1. How the BHC process improves atom economy, step economy, and reduces hazardous waste. 2. The role of catalysis (acid and hydrogenation catalysts) in reducing environmental impact. 3. Which principles of green chemistry are clearly demonstrated in the BHC route. 4. Why this greener process is more suitable for large-scale industrial production.

- **References**

1. Organic Chemistry, Clayden Greeves Warren and Wothers Oxford Press (2001).
2. Organic reactions and their mechanisms, 3rd revised edition, P.S. Kalsi, New Age International Publishers.
3. Green Chemistry: An Introductory Text, 2nd Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.
4. Green chemistry, Theory and Practical, Paul T. Anastas and John C. Warner.
5. New trends in green chemistry By V. K. Ahulwalia and M. Kidwai, 2nd edition, Anamaya Publishers, New Delhi.

<table>
<tr><td>BOS</td><td colspan="5">Natural and Physical Sciences</td></tr>
<tr><td>Course</td><td colspan="5">COMBINED SPECTRAL ANALYSIS</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">HPSCY205P</td><td>Level</td><td colspan="3">6.5</td></tr>
<tr><td>Type</td><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Semester</td><td>III</td><td>Credits</td><td>-</td><td>2</td><td>2</td></tr>
<tr><td>Type</td><td>Elective</td><td>No. of Teaching hours</td><td>-</td><td>60</td><td>60</td></tr>
<tr><td rowspan="2">Evaluation Pattern</td><td>Total Marks</td><td>Semester End</td><td>Continuous</td><td colspan="2">Practical</td></tr>
<tr><td>50</td><td>-</td><td>-</td><td colspan="2">50</td></tr>
</table>

Learning Objectives	
1	Determination of molecular formula from mass spectrometry.
2	Analysis of spectral data from various spectra.
3	Elucidate structures of organic compounds using combined data from various spectroscopic techniques.

Course Outcomes	
CO1	Use various spectroscopic techniques to elucidate the structure of organic compounds

Modules At Glance

Module No.	Content	No. of Hours	CO Mapping
I	Combined Spectral Identification	60	CO1
		60	

Syllabus

Module No.	Content
I	Interpretation of spectral data of organic compounds (UV, IR, PMR, CMR and Mass spectra) (Molecular formula to be determined using rule of 13/elemental composition method). A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which the student is expected to determine molecular formula and preliminary information and report it within the first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc (Minimum 10 spectral analysis)

Note:

1. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily.

The list of the experiments performed by the candidate should be attached with such a certificate.

3. Use of non-programmable calculators is allowed both at the theory and the practical examination.

References: 1. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Practical Evaluation (50 Marks)

	Assessment/ Evaluation	Marks
1	Practical	40
2	Journal & viva	10

BOS	**Natural and Physical Sciences**					
Course	**GREEN CHEMISTRY PRACTICAL**					
Course Code	**HPSCY206P**		**Level**	**6.5**		
			Type	**Theory**	**Practical**	**Total**
Semester	**III**		**Credits**	**-**	**2**	**2**
Type	**Major: Elective**		**No. of Teaching hours**	**-**	**60**	**60**
Evaluation Pattern	**Total Marks**	**Semester End**	**Continuous**	**Practical**		
	50	**-**	**-**	**50**		

Learning Objectives	
1	Apply the principles of green chemistry in laboratory experiments, including the selection and use of green solvents, reagents, and catalysts to design safer and more sustainable chemical processes.
2	Evaluate the environmental impact of traditional versus green synthetic methods to assess and improve chemical processes for reduced waste and hazard.

Course Outcomes	
CO1	Identify solvent-free reactions using appropriate techniques and equipment.
CO2	Optimize green chemistry reactions in the laboratory
CO3	Analyze the advantages and disadvantages of solvent-free reactions, green catalysts, and green solvents in comparison to traditional chemical methodologies.

Modules At Glance

Module No.	Content	No. of Hours	CO Mapping
I	Green Chemistry practical	60	CO1, CO2, CO3
		60	

Syllabus

Sr.No	Contents
1	Preparation of acetanilide using aniline (Ref 2. Pg 11) done
2.	Preparation of Benzilic Acid in Solid State under Solvent-free Condition (Ref 2. Pg 20) done
3.	Transesterification reaction: synthesis of biodiesel (Ref 2. Pg 42)
4.	Knoevenagel condensation (Ref no. 1, Page 51)
5.	Synthesis of dihydropyrimidinone (Ref.No.2, Page no.40) done
6.	Beckmann rearrangement (Ref no. 1, Page 346) done
7.	Solvent free oxidation of alcohol by using sodium dichromate (Ref 1. 24)
8.	Preparation of 1, 1-bis-2-naphthol from 2-naphthol. (ref1. Pg 33, Ref.No.2 Page no.36) done
9.	Pinacol coupling reaction by using Zn-ZnCl2 (Ref.No.1 Page no.35)
10.	Reformatsky reaction reaction (Ref.No.1 Page no.36)
11.	Base catalysed Aldol condensation: Synthesis of Dibenzalpropanone (Ref. no. 2) done
12.	Synthesis of tetrabutylammonium tribromide and its application in bromination of chalcone (Ref. no. 2)

References

1. Solvent-free Organic Synthesis by Koichi Tanaka (Copyright © 2009 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 978-3-527-32264-)
2. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST

Practical Evaluation (50 Marks)

	Assessment/ Evaluation	**Marks**
1	Practical	40
2	Journal & Viva	10

<table>
<tr><td>BOS</td><td colspan="5">Natural and Physical Sciences</td></tr>
<tr><td>Course</td><td colspan="5">Research Project</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">HPSCY207</td><td>Level</td><td colspan="3">6.5</td></tr>
<tr><td>Type</td><td>Theory</td><td>Research Project</td><td>Total</td></tr>
<tr><td>Semester</td><td>III</td><td>Credits</td><td>-</td><td>4</td><td>4</td></tr>
<tr><td>Type</td><td>Experiential Learning</td><td>No. of hours</td><td>-</td><td>120</td><td>120</td></tr>
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<tr><td rowspan="2">Evaluation/ Assessment</td><td>Total Marks</td><td>External evaluation</td><td>Continuous</td><td>Practical</td></tr>
<tr><td>100</td><td>50</td><td>50</td><td>-</td></tr>
</table>

Learning Objectives	
1	To think critically, analyze data, and develop well-supported arguments, helping them to refine their problem-solving abilities.
2	To contribute original research that adds to the existing body of knowledge in their field, advancing academic scholarship.
3	Gain hands-on experience in research methodologies, data collection, analysis, and interpretation, which are crucial skills for future academic or professional endeavors.
4	Exploring intersections of various disciplines, promoting interdisciplinary learning and broadening students' intellectual horizons.
5	The research fosters creativity and innovation by encouraging students to address current problems, explore new solutions, and apply their findings in real-world contexts.

Course Outcomes	
CO1	Students develop expertise in research methodologies, critical thinking, data analysis, and problem-solving, preparing them for advanced academic and professional pursuits.
CO2	The research generates new knowledge, insights, or innovations in the chosen field, addressing existing gaps and expanding current understanding.
CO3	Completion of the research project strengthens academic credentials and professional competence, enabling progression to leadership roles, higher studies, or specialized careers.
CO4	The work may result in publications, conference presentations, or academic recognition, enhancing the student’s visibility and contribution to scholarly discourse.

Credits and Duration:

▪ Students are to work on research projects individually and should be the continuity of the research project selected in the semester.
▪ For semester III, Research Project is of 4 credits which equals to project working hours of 120.
▪ Students should devote enough time for their project work (08 hours each week).
▪ Record of attendance and continuous performance of the student is required to be monitored by the mentor.
• The research project is to be completed during Semester III independently. According to the guidelines outlined in the National Education Policy (NEP), Post graduate students are expected to fulfill this requirement in the third semester of their PG program.

Project (Dissertation) Report:

Students are required to submit a report of the research project at the end of the semester in the following suggested format.
A project dissertation should be typed on A4 sheets, Font Size 12, Times New Roman, one and a half spacing on executive bond paper. The project report shall have an appropriate chapter scheme and be presented in a minimum of 30-40 pages. The report should be arranged in the following manner.

Title Page
● Title of the Report (Font size 14)
● Name of the Student
● Roll number/Seat number
● Project Title
● Name of the Mentor
● Month of Submission

Certificate by the Institute
Certificate by Mentor
Student's Declaration
Acknowledgement
Abstract
● A brief summary of the Project, key observations, and main conclusions (200-300 words).

Table of Contents
● Include headings and subheadings with page numbers.

List of Figures and Tables
● List all figures and tables included in the report with corresponding page numbers.

Chapter 1: Introduction
● Purpose of the research project: Outline the objectives and expected outcomes of the project.
● Background Information: Provide context about the project work and its significance.
● Scope of the Report: Define the boundaries of what the report will cover.

Chapter 2: Literature Review
● Review relevant literature on previous studies, and critical analyses of the literary significance.

Chapter 3: Proposed Methodology
● Describe the approach and methods for data collection of the work.
● Discuss the rationale behind the chosen methods.

Chapter 4: Research Work Plan

● Provide detailed descriptions of work to be carried out in Sem IV.
● Include literature and expected observations related to the work relevance to the topic selected.
● Use photographs, diagrams, reactions, etc. to support the descriptions.
● Analyze the data collected in relation to the study objectives.

Chapter 5: Conclusion and Recommendations
● Discuss how the findings from the work contribute to the understanding of the subject area.
● Summarize the key findings and their significance.
● Offer recommendations based on the research findings for further study or preservation efforts.

References
● List all sources cited in the report in a consistent format.

Appendices
● Include additional data, notes, or documents that are relevant to the report but not integral

Evaluation of Research Project:

Evaluation during the research project involves two key components: External Evaluation (50%) and Internal Evaluation (50%) for the semesters.

Continuous Evaluation (50 Marks)

	Assessment/ Evaluation	Marks
1	Selection of the project	10
2	Literature survey	25
3	Scheme /Outline of project/Proposed Methodology	15

Evaluation by external examiner (50 Marks)

	Assessment/ Evaluation	Marks
1	Report/Presentation	15
2	Dissertation	20
3	Viva	15