

*Academic Council dated 09<sup>th</sup> and 11<sup>th</sup> March, 2024 as per Item Number: 1.07*



**DOMBIVLI SHIKSHAN PRASARAK MANDAL'S,  
K.V. PENDHARKAR COLLEGE OF ARTS, SCIENCE AND COMMERCE,  
(AUTONOMOUS) DOMBIVLI (EAST), DIST. THANE  
(Affiliated to University of Mumbai)**

**Faculty of Science**

**DEPARTMENT OF CHEMISTRY**

**(Programme: Master of Science, M.Sc.)**

**SYLLABUS FOR**

**M. Sc. – Organic Chemistry (Semester III and IV)**

**Choice Based Credit System (CBCS)**

**(With effect from the Academic Year: 2024-2025)**

Sr. No.	Course Code	Course Title	Category	Teaching hours/week	Total Marks	Credits
<b>Semester III</b>						
1	CH24301MM	Paper –I (Theoretical Organic Chemistry-I)	Mandatory	4	100	4
2	CH24302MM	Paper –II (Synthetic Organic Chemistry-I)	Mandatory	4	100	4
3	CH24303MM	Paper-III ( Natural Products and Spectroscopy)	Mandatory	4	100	4
4	CH24304EL	Paper-IV (Medicinal, Green & Computational Chemistry-I) OR Paper-IV (Intellectual Property Right)	Elective	2	100	2
5	CH24305RP	Research Project	Research Project	4	100	2
6	CH24306MM	Organic Chemistry Practical	Mandatory	4	100	2
7	CH24307EL	Practical's in Single Step Synthesis	Elective	4	100	2
<b>Semester IV</b>						
1	CH24401MM	Paper –I (Theoretical Organic Chemistry-II)	Mandatory	4	100	4
2	CH24402MM	Paper –II (Synthetic Organic Chemistry and Microscopy of surface Chemistry)	Mandatory	4	100	4
3	CH24403EL	Paper-III (Natural Products and Heterocyclic Chemistry) OR Paper-III (Bio-Organic Chemistry-I)	Elective	4	100	4
4	CH24404RP	Research Project	Research Project	12	200	6
5	CH24405MM	Practical's in Two Step Synthesis	Mandatory	4	100	2
6	CH24406MM	Practical's in Characterization of organic compounds	Mandatory	4	100	2

		<b>Total Credit</b>	<b>44</b>
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**Program outcomes:**

On successful completion of this program students

**PO 1.** Will be able to think critically and creatively, divergently, and convergently, to propose novel ideas in explaining facts or providing new solution to the problems in chemistry.

**PO 2.** Will achieve scientific temperament to plan and execute projects independently with lateral possibilities.

**PO 3.** Will have expertise in operating various instruments employing Good Laboratory Practices.

**PO 4.** Will be an exuberant team member excelling in collaborative skills and leadership.

**PO 5.** Will be competent to opt for jobs offered to M.Sc. candidates.

**PO 6.** Will be confident to undertake research as a career and be able to join Ph.D. courses.

**PO 7.** Will be able to qualify for various competitive examinations post M.Sc.

**PO 8.** Start-up will be a good option for many.

**Program Specific Outcomes**

On successful completion of this specific program students:

**POS 1.** Due to the scientific and analytical temperament, will have mastery over the fundamental aspects of the various core areas of Chemistry.

**POS 2.** Will be able to analyse the various observations and chemical phenomena, investigate, plan, and execute unexplored experimentations with innovation.

**POS 3.** Will have thorough knowledge and skills in preparing and handling chemicals, reagents, apparatus, instruments and the care and safety aspects involved in such handling using Good Laboratory Practices.

**POS 4.** Due to their hands-on experience in various processes, innovative projects with emphasis on Green Chemistry and environment will be a definite choice in the frontiers of research.

**POS 5.** Being an excellent team member, with collaborative skills and leadership qualities will be a good choice for industries.

**POS 6.** Will be eligible for Ph.D. courses in Chemistry and venture in the start-ups.

## Semester – III

### Paper I-Theoretical organic chemistry-I (CH24301MM)

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- Organic reaction mechanisms	15	4
2	Unit-II- Pericyclic reactions	15	
3	Unit-III- Stereochemistry I	15	
4	Unit-IV- Photochemistry I	15	

#### Learning objectives:

The learner to be imparted with:

1. Knowledge of various types of mechanism of the reactions.
2. Understanding to determine the symmetry of a molecule.
3. Define photochemical reactions, describe the uses of photochemistry.
4. Understand the Construction of molecular orbitals of molecules.
5. Detail study of various types of reactions.

#### Learning outcomes:

On successful completion of this course students will be able to:

1. Predict the stability of intermediates and the pathway of reaction mechanisms.
2. Apply the concept of stereochemistry in pericyclic reactions.
3. Analyse the stereochemistry of molecules and carry out conformational analysis of ring compounds.
4. Apply the principles of photochemistry.

Units	Topics	Lectures
UNIT I	<p><b>Organic reaction mechanisms</b></p> <p><b>1.1 Organic reactive intermediates:</b> methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes. [5L]</p> <p><b>1.2 Carbon-Carbon double bond formation:</b> Julia-Lythgoe olefination, carbonyl coupling reaction (McMurry reaction), Tebbe's reagent, Shapiro and related reactions. Carbon-Carbon triple bond formation: from strained rings, Eschenmosher fragmentation, allenes. [3L]</p> <p><b>1.3 Role of FMOs in organic reactivity:</b> Reactions involving hard and soft electrophiles and nucleophiles, ambident nucleophiles, ambident electrophiles, the <math>\alpha</math> effect [2L]</p> <p><b>1.4 Pericyclic reactions:</b></p> <p>1.4.1 Classification of pericyclic reactions; thermal and photochemical reactions. Three approaches</p> <p>1.4.2 Evidence for the concertedness of bond making and breaking Symmetry-Allowed and Symmetry-Forbidden Reactions</p> <ul style="list-style-type: none"> <li>• The Woodward-Hoffmann Rules-Class by Class</li> <li>• The generalised Woodward-Hoffmann Rule</li> </ul> <p>Explanations for Woodward-Hoffmann Rules</p> <ul style="list-style-type: none"> <li>• The Aromatic Transition structures [Huckel and Mobius]</li> <li>• Frontier orbitals [5L]</li> </ul>	<b>15</b>

UNIT II	<p>Pericyclic reactions</p> <p><b>2.1</b> Cycloaddition reactions: Supra and anta facial additions, <math>4n</math> and <math>4n+2</math> systems, <math>2+2</math> 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.</p> <p>Other Cycloaddition Reactions- [4+6] Cycloadditions, Ketene Cycloaddition, Allene Cycloadditions, Carbene Cycloaddition, Epoxidation and Related Cycloadditions. Other Pericyclic reactions: Sigmatropic Rearrangements, Electrocyclic Reactions, Alder 'Ene' Reactions. [7L]</p> <p><b>2.2</b> Electrocyclic reactions: Conrotatory and disrotatory motions, <math>4n\pi</math> and <math>(4n+2)\pi</math> electron and allyl systems.[3L]</p> <p><b>2.3</b> 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. [5L]</p>	15
UNIT III	<p>Stereochemistry-I</p> <p><b>3.1</b> Classification of point groups based on symmetry elements with examples (nonmathematical treatment). [2L]</p> <p><b>3.2</b> Conformational analysis of medium rings: Eight to ten membered rings and their unusual properties, I-strain, transannular reactions. [3L]</p> <p><b>3.3</b> Stereochemistry of fused ring and bridged ring compounds: Decalins, Hydrindanes, Perhydroanthracenes, steroids, and Bredt's rule. [5L]</p> <p><b>3.4</b> 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 <math>\text{LiAlH}_4</math>, Selectride and MPV reduction) and oxidation of cyclohexanols. [5L]</p>	15

UNIT IV	<p><b>Photochemistry</b></p> <p><b>4.1</b> Principles of photochemistry: Quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process. [3L]</p> <p><b>4.2</b> Photochemistry of carbonyl compounds: <math>\pi \rightarrow \pi^*</math>, <math>n \rightarrow \pi^*</math> transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, Photochemistry of enones, Photochemical rearrangements of <math>\alpha</math>, <math>\beta</math>-unsaturated ketones and Cyclohexadienones. Photo Fries rearrangement, Barton reaction. [8L]</p> <p><b>4.3</b> Photochemistry of olefins: cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di-<math>\pi</math>-methane rearrangement including aza-di-<math>\pi</math>-methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation of alkenes. [2L]</p> <p><b>4.4</b> Photochemistry of arenes: 1,2-, 1,3- and 1,4- additions. Photocycloadditions of aromatic Rings. [1L]</p> <p><b>4.5</b> Singlet oxygen and photo-oxygenation reactions: Photochemically induced Radical Reactions, Chemiluminescence. [1L]</p>	15
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**Justification:**

Students could learn about carbon-carbon double and triple bond formation instead of repetitive learning PMO of ethylene 1,3-butadiene, 1,3,5-hexatriene and allyl system.

**Learner's space:**

1. Can explain the reaction mechanism pathway.
2. Introduction of pericyclic reactions.
3. Can predict the stereochemistry of products.
4. Photochemistry of carbonyl compounds, olefins and arenes.

**Job oriented/Entrepreneurship development topics:** Synthesis of organic reactions and its application in various fields.

**References:**

1. March's advanced organic chemistry, Jerry March, 6<sup>th</sup> edition, 2007, John Wiley and sons.
2. A guide to mechanism in organic chemistry, 6<sup>th</sup> edition, 2009, Peter Sykes, Pearson education, New Delhi.
3. Advanced organic chemistry: Reaction mechanisms, R. Bruckner, Academic Press (2002).
4. Organic reaction mechanism, 4<sup>th</sup> edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.
5. Reaction mechanism in organic chemistry, S. M. Mukherji, S. P. Singh, Macmillan Publishers, India.
6. Organic Chemistry, Part A and B, 5<sup>th</sup> edition, 2007, Francis A. Carey and Richard J. Sundberg, Springer.

7. Carbenes, nitrenes and arynes. Von T. L. Gilchrist, C. W. Rees. Th. Nelson and Sons Ltd., London 1969.
8. Organic chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1<sup>st</sup> Edition, Oxford University Press (2001).
9. Organic chemistry, 7<sup>th</sup> Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.
10. Organic reactions & their mechanisms, 3<sup>rd</sup> revised edition, P.S. Kalsi, New Age International Publishers.
11. Pericyclic reactions, S. Sankararaman, Wiley VCH, 2005.
12. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011.
13. Pericyclic reactions, Ian Fleming, Oxford University press, 1999.
14. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
15. Organic chemistry, 8<sup>th</sup> edition, John McMurry.
16. Modern methods of organic synthesis, 4<sup>th</sup> Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004.
17. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books, 2006.
18. Stereochemistry of carbon compounds: Principles and Applications, D, Nasipuri, 3<sup>rd</sup> edition, New Age International Ltd.
19. Stereochemistry of organic compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India edit.
20. Stereochemistry, P. S. Kalsi, 4<sup>th</sup> edition, New Age International Ltd.
21. Organic stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005.
22. Fundamentals of photochemistry, K. K. Rohtagi-Mukherji, Wiley Eastern.
23. Essentials of molecular photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
24. Molecular photochemistry, N. J. Turro, W. A. Benjamin.
25. Introductory photochemistry, A. Cox and T. Camp, McGraw-Hill.
26. Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
27. Organic photochemistry, J. Coxon and B. Halton, Cambridge University Press.
28. Molecular orbitals and organic chemical reactions by Ian Fleming (Wiley- A john Wiley and Sons, Ltd., Publication).

#### **ICT Backup:**

1. <https://youtu.be/Ih7tQ7rY2Wc>
2. <https://youtube.com/playlist?list=PLyqSpQzTE6M936966RyQjOXvv1QlhZW3H>
3. [https://youtu.be/p\\_BMWRaL62w](https://youtu.be/p_BMWRaL62w)
4. <https://youtu.be/IUkUTF5ukbU>
5. <https://youtube.com/playlist?list=PLYXnZUqtB3K9-SOwqZiHigO8leI6qMZX>

#### **Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform- Swayam Pericyclic Reactions <a href="https://onlinecourses.nptel.ac.in/noc23_cy11/previous">https://onlinecourses.nptel.ac.in/noc23_cy11/previous</a>	8 weeks	95%	Free
2. Platform- Swayam Stereochemistry <a href="https://onlinecourses.nptel.ac.in/noc23_cy23/previous">https://onlinecourses.nptel.ac.in/noc23_cy23/previous</a>	8 weeks	50%	Free

**Paper II- Synthetic organic chemistry-I (CH24302MM)**

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- Name reactions with mechanism and application	15	04
2	Unit-II- Radicals in organic synthesis	15	
3	Unit-III-Enamines, Ylides and cyclic compounds	15	
4	Unit-IV-Metals / Non-metals in organic synthesis and carbon nanomaterials	15	

**Learning objectives:**

The learner to be imparted with:

1. The different types of name reaction and mechanism.
2. Understand the organic synthesis.
3. Knowledge of synthesis of Enamines, Ylides and cyclic compound.
4. Understand the organometallic and nanomaterials.
5. Detail study of various types of reactions.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Write mechanism for various coupling reactions including multicomponent reactions and Click reaction.
2. Apply the method of preparing important compounds involving radicals.
3. Apply the method for preparing synthetically important compounds via enamines and ylides including synthesis of cyclic compounds.
4. Explore the applications of various metals and non-metals in organic synthesis also carbon nanomaterials.

Units	Topics	Lectures
<b>UNIT I</b>	<b>Name reactions with mechanism and application</b>	<b>15</b>
	<b>1.1 Multicomponent reactions:</b> Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis [5L] <b>1.2 Click Reactions:</b> Characteristics; Huisgen 1,3-Dipolar	

	<p>Cycloaddition</p> <p>1.2.1 Stille reaction, Saeguse-Ito oxidation to enones, Negishi coupling</p> <p>cross coupling reactions (Suzuki, Kumada, Hiyama, Sonogashira, Buchwald-Hartwig),</p> <p>1.2.2 Fischer carbenes, Schrock carbenes, Mukaiyama aldol reaction</p> <p>1.2.3 Doz benzoannulation, Pauson-Khand reaction. [10L]</p>	
<b>UNIT II</b>	<b>Radicals in organic synthesis</b>	<b>15</b>
	<p><b>2.1 Introduction:</b> Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals. [3L]</p> <p><b>2.2 Radical Initiators:</b> Azobisisobutyronitrile (AIBN) and dibenzoylperoxide.[1L]</p> <p><b>2.3 Characteristic reactions:</b> Free radical substitution, addition to multiple bonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity), radical cyclizations, autoxidations: synthesis of cumene hydroperoxide from cumene. [4L]</p> <p><b>2.4 Radicals in synthesis:</b> Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds. Oxidative coupling, C-C bond formation in aromatics: <math>S_N^{Ar}</math> reactions. [4L]</p> <p><b>2.5 Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation. [3L]</b></p>	
<b>UNIT III</b>	<b>Enamines, Ylides and cyclic compounds</b>	<b>15</b>
	<p><b>3.1 Enamines:</b> Generation &amp; application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison between enamines and enolates. Synthetic reactions of enamines. [3L]</p> <p><b>3.2 Phosphorus, Sulfur and Nitrogen Ylides:</b> Preparation and their synthetic applications along with their stereochemical aspects. Wittig reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination. [6L]</p> <p><b>3.3 Synthesis of cyclic compounds</b></p> <p><b>4-Membered rings:</b> Various methods of forming cyclobutanes, cyclobutenes.</p> <p><b>5-Membered rings:</b> intramolecular <math>S_N^2</math> reactions, intramolecular Michael and aldol condensation reactions, intramolecular Wittig olefination, ring expansion and contraction reactions, 1,3 -dipolar cycloaddition reactions, Nazarov cyclization, arene-olefin photocycloaddition, radical cyclization reactions.</p> <p><b>6-Membered rings:</b> o-quinodimethanes, cation olefin cyclization, Robinson annulations. [6L]</p>	
<b>UNIT IV</b>	<b>Metals / Non-metals in organic synthesis and carbon nanomaterials</b>	<b>15</b>
	<p><b>4.1 Organosilicons:</b> Salient features of silicon governing the reactivity of organosilicons, preparation and important bond-forming reactions of alkyl silanes, alkenyl silanes, aryl silanes and allyl silanes. <math>\beta</math>-silyl cations as intermediates. Iodotrimethylsilane</p>	

	<p>in organic synthesis.[3L]</p> <p><b>4.2 Organotin compounds:</b> Preparation of alkenyl and allyl tin compounds; application in C-C bond formation, in replacement of halogen by H at the same C atom. [2L]</p> <p><b>4.3 Selenium in organic synthesis:</b> Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and seleno acetals as <math>\alpha</math>-C-H activating groups [2L]</p> <p><b>4.4 Advances in Carbon Nanomaterials:</b></p> <p>(a) Types of carbon nanomaterials, e.g. nanotubes, nanorods, solid spheres, core-shell, carbon nanofibers, graphene, graphyne, nanoporous, mesoporous and macroporous.</p> <p>(b) Properties of carbon nanomaterials.</p> <p>(c) Methods of preparation with emphasis on preparation of carbon nanomaterials from vegetable oils by CCVD technique.</p> <p>(d) Applications of nanomaterials in electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defence. [8L]</p>	
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**Justification:**

The reactions which were already in previous class are replaced with some important coupling reactions. Replacing  $\alpha$ -CH functionalization by synthesis of cyclic compounds so that students will learn about the different cyclization reactions. As mercury and organoboron compounds are in previous classes so it is rearranged by organosilicons and organotin compounds in old syllabus and silyl enol ethers, mercury, organoboron and silyl enol ethers is replaced by Advances in carbon nanomaterials as Carbon nanomaterial have important applications in various fields.

**Learner's space:**

1. Introduction of some coupling reactions, multicomponent synthesis.
2. Characteristics of radicals and their role in organic synthesis.
3. Synthesis of cyclic compounds, enamines and phosphorus, sulfur and nitrogen ylides.
4. Use of metal, non-metal in organic synthesis and advances in carbon nanomaterials.

**Job oriented/Entrepreneurship development topics:** Wide scope in carbon nanomaterials and nanotechnology, different name reactions with mechanisms.

**References:**

1. Advanced organic chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5<sup>th</sup> Edition, Springer Verlag.
2. Modern methods of organic synthesis, 4<sup>th</sup> Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.
3. Chem. Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis, S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam.
4. Organic chemistry, Clayden Greeves Warren and Wothers, Oxford Press (2001).
5. Modern organic synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
6. Advanced organic chemistry: Reaction Mechanism, R. Bruckner, Academic Press (2002).

- Principles of organic synthesis, R.O.C. Norman & J. M. Coxon, 3<sup>rd</sup> Edition, Nelson Thornes.
- Organic chemistry, 7<sup>th</sup> Edn, R. T. Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson.
- Strategic applications of name reactions in organic synthesis, L. Kurti & B. Czako (2005), Elsevier Academic Press.
- Advanced organic chemistry: Reactions & mechanisms, 2<sup>nd</sup> Edn, B. Miller & R. Prasad, Pearson.
- Organic reactions and their mechanisms, 3<sup>rd</sup> revised edition, P.S. Kalsi, New Age International Publishers.
- Organic synthesis: The disconnection approach, Stuart Warren, John Wiley & Sons, 2004.
- Name reactions and reagents in organic synthesis, 2<sup>nd</sup> Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience.
- Name reactions, Jie Jack Lie, 3<sup>rd</sup> Edn. Springer.
- Organic electrochemistry, H. Lund, and M. Baizer, 3<sup>rd</sup> Edn. Marcel Dekker.

#### ICT Backup:

- <https://youtu.be/fcpQ-XFTFUA>
- <https://youtu.be/QU0BRxiqtu8>
- <https://youtu.be/8IMFV0Vj6jE>
- [https://youtube.com/playlist?list=PLB6GKhKKVn3WV8lf\\_As-dZJL4nxYJoJL0](https://youtube.com/playlist?list=PLB6GKhKKVn3WV8lf_As-dZJL4nxYJoJL0)

**Pedagogy:** Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

#### MOOC:

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform-Udemy Nanomaterials <a href="https://www.udemy.com/course/nanomaterials/">https://www.udemy.com/course/nanomaterials/</a>	16 lectures	50%	Rs.799/-

### Paper III- Natural products and spectroscopy (CH24303MM)

Sr. No.	Units	Lectures	Credit Points
1	Unit I- Natural products-I	15	4
2	Unit II- Natural Product II	15	
3	Unit III- Advanced spectroscopic techniques-I	15	
4	Unit IV- Advanced spectroscopic techniques-II	15	

#### Learning objectives:

The learner to be imparted with:

- Explanation of occurrence, and structure elucidation and application of carbohydrates.
- Structure elucidation of natural pigments.

3. Concepts of  $^1\text{H-NMR}$  spectroscopy so that they can predict number of protons and their environment in the molecules.
4. Study of the advanced NMR techniques.
5. Interpretation of IR spectroscopy data to identify new compounds.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Evaluate the structure of carbohydrates, alkaloids.
2. Learn the various methods for the synthesis of natural pigments, pheromones etc.
3. Acquire knowledge about spectroscopic techniques.
4. Have spectral problem-solving approach.

Units	Topics	Lectures
<b>UNIT I</b>	<b>Natural products- I</b>	<b>15</b>
	<p><b>1.1 Carbohydrates:</b> Introduction to naturally occurring sugars: Deoxysugars, aminosugars, branched sugars. Structure elucidation of lactose and Dglucosamine (synthesis not expected). Structural features and applications of inositol, starch, cellulose, chitin and heparin. [5L]</p> <p><b>1.2 Natural pigments:</b> General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of <math>\beta</math>-carotene and Cyanin (with synthesis). Synthesis of ubiquinone from 3, 4, 5-trimethoxyacetophenone. [5L]</p> <p><b>1.3 Insect pheromones:</b> General structural features and importance. Types of pheromones (aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of Bombykol from acetylene, Disparlure from 6-methylhept-1-ene, Grandisol from 2-methyl-1, 3-butadiene. [3L]</p> <p><b>1.4 Alkaloids:</b> Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of coniine. [2L]</p>	
<b>UNIT II</b>	<b>Natural products-II</b>	<b>15</b>
	<p><b>2.1 Multi-step synthesis of natural products:</b> Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations: [8L]</p> <p>a) Woodward synthesis of Reserpine from benzoquinone</p> <p>b) Corey synthesis of Longifoline from resorcinol</p> <p>c) Gilbert-Stork synthesis of Griseofulvin from phloroglucinol</p> <p>d) Corey's Synthesis of Caryophyllene from 2-Cyclohexenone and Isobutylene</p> <p>e) Synthesis of Juvabione from Limonene</p> <p>f) Synthesis of Taxol.</p> <p><b>2.2 Prostaglandins:</b> Classification, general structure and biological importance. Structure elucidation of PGE1.[2L]</p> <p><b>2.3 Lipids:</b> Classification, role of lipids, Fatty acids and glycerol</p>	

	<p>derived from oils and fats. [2L]</p> <p><b>2.4 Insect growth regulators:</b> General idea, structures of JH2 and JH3 [1L]</p> <p><b>2.5 Plant growth regulators:</b> Structural features and applications of arylacetic acids, gibberellic acids and triacontanol. Synthesis of triacontanol (synthesis of stearyl magnesium bromide and 12-bromo-1- tetrahydropyranloxydodecane expected).[2L]</p>	
<b>UNIT III</b>	<b>Advanced spectroscopic techniques-I</b>	<b>15</b>
	<p><b>3.1 Proton NMR spectroscopy:</b> Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (<math>A_2</math>, AB, AX, <math>AB_2</math>, <math>AX_2</math>, AMX and <math>A_2B_2-A_2X_2</math> spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and coupling in aromatic and heteroaromatic systems), Temperature effects, Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents. [7L]</p> <p><b>3.2 <math>^{13}C</math> –NMR spectroscopy:</b> Recapitulation, equivalent and non-equivalent carbons (examples of aliphatic and aromatic compounds), <math>^{13}C</math>- chemical shifts, calculation of <math>^{13}C</math>- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to <math>^{19}F</math> and <math>^{31}P</math>. [4L]</p> <p><b>3.3 Spectral problems</b> based on UV, IR, <math>^1H</math>NMR and <math>^{13}C</math>NMR and Mass spectroscopy. [4L]</p>	
<b>UNIT IV</b>	<b>Advanced spectroscopic techniques-II</b>	<b>15</b>
	<p><b>4.1 Advanced NMR techniques:</b> 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. [10L]</p> <p><b>4.2 Spectral problems</b> based on UV, IR, <math>^1H</math>NMR, <math>^{13}C</math>NMR (Including 2D technique) and Mass spectrometry. [5L]</p>	

**Justification:**

No change in paper III.

**Learner's space:**

1. Evaluation of structures, characteristics, and synthesis of natural products.
2. Analyse the concepts in spectroscopic techniques and their types.
3. Learners will able to solve the problems based on spectral data.

**Job oriented/Entrepreneurship development topics:** Carbohydrates, natural pigments, insect growth regulators, plant growth regulators, NMR spectroscopy, advanced NMR techniques, spectral problems based on spectroscopic techniques.

**References:**

1. Natural product chemistry, a mechanistic, biosynthetic, and ecological approach, Kurt B. G. Torssell, Apotekarsocieteten – Swedish Pharmaceutical Press.
2. Natural products chemistry and applications, Sujata V. Bhat, B. A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.

3. Organic chemistry, natural products, Volume-II, O. P. Agarwal, Krishna Prakashan, 2011.
4. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974.
5. Natural product chemistry Vol.1 and 2, K. Nakanishi J. Goto. S. Ito Majori and S. Nozoo, Academic Press, 1974.
6. Chemistry of natural products, V. K. Ahluwalia, Vishal Publishing Co. 2008.
7. Heterocyclic chemistry, 3<sup>rd</sup> edition, Thomas L. Gilchrist, Pearson Education, 2007.
8. Heterocyclic Chemistry, Synthesis, reactions and mechanisms, R. K. Bansal, Wiley Eastern Ltd., 1990.
9. Heterocyclic chemistry, J. A. Joule and G. F. Smith, ELBS, 2<sup>nd</sup> edition, 1982.
10. The conformational analysis of heterocyclic compounds, F. G. Riddell, Academic Press, 1980.
11. An introduction to the chemistry of heterocyclic compounds, 2<sup>nd</sup> edition, B. M. Acheson, 1975.
12. Natural products: Chemistry and biological significance Inter science, J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthrope and J. B. Harborne, Longman, Essex, 1994.
13. Organic chemistry, Vol 2, I. L. Finar, ELBS, 6<sup>th</sup> edition, Pearson.
14. Stereoselective synthesis: A practical approach, M. Nogradi, Wiley-VCH, 1995.
15. Product chemistry, Atta-ur-Rahman and M. I. Choudhary, Harwood Academic Publishers, 1998.
16. Insecticides of natural origin, Sukh Dev, Harwood Academic Publishers.
17. Total synthesis of longifolene, J. Am. Chem. Soc., E. J. Corey, M. Ohno, R. B. Mitra, and P. A. Vatakencherry. 1964, 86, 478.
18. The structure and total synthesis of 5-Vetivone, J. A. Marshall and P. C. Johnson, J. Org. Chem., 35, 192 (1970).
19. Total synthesis of spirovetivanes, J. Am. Chem. Soc. 1967, 89, 2750.
20. The alkaloids, The fundamental chemistry, A biogenetic approach, Marcel Dekker Inc. New York, 1979.
21. Comprehensive organic chemistry by Barton and Ollis, Pergamon Press, Oxford, 1979.
22. Medicinal natural products, a biosynthetic approach, Derick Paul, John Wiley and Sons, 2002.
23. Biosynthesis of natural products, Mannitto Paolo, Ellis Horwood Limited, 1981.
24. Selected organic synthesis, Ian Fleming, John Wiley and Sons, 1973.
25. Total synthesis of natural products, J. Apsimon, John Wiley and Sons.
26. Spectroscopy of organic compounds, P. S. Kalsi, New Age International Pub. Ltd. And Wiley Eastern Ltd., Second edition, 1995.
27. Applications of absorption spectroscopy of organic compounds, J. R. Dyer, Prentice Hall of India, 1987.
28. Spectrometric identification of organic compounds, R. M. Silverstein and others, John Wiley and Sons Inc., 5<sup>th</sup> ed., 1991.
29. Absorption spectroscopy of organic molecules, V. M. Parikh, 1974.
30. Spectroscopic methods in organic chemistry, Williams and Fleming, Tata McGraw Hill, 4<sup>th</sup> Edn, 1989.
31. Organic spectroscopy, William Kemp, ELBS, 3<sup>rd</sup> ed., 1987.
32. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4<sup>th</sup> edn., .2011.

33. Introduction to spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, 4<sup>th</sup> ed., 2009.
34. Organic spectroscopy: Principles and applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004.
35. Structure determination of organic compounds, E. Pretsch, P. Buhlmann, C. Affolter, Springer.

**ICT Backup:**

1. <https://youtu.be/awptCdzqXuo>
2. <https://youtu.be/2vDAyBCa5NE>
3. <https://youtu.be/d1AUcEXiIXk>
4. <https://youtu.be/vQOKZTJHPGk>
5. <https://youtu.be/Owb5q1ohlYo>

**Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform- Udemy Organic spectroscopy <a href="https://www.udemy.com/course/introductory-organic-chemistry-spectroscopy/">https://www.udemy.com/course/introductory-organic-chemistry-spectroscopy/</a>	3hr. 55 min	40%	Rs. 999/-

**Paper IV- Medicinal, green chemistry and computational chemistry**

Sr. No.	Units	Lectures	Credit Point
1	Unit-I- Drug design, development and synthesis	10	
2	Unit-II-Green Chemistry	10	
3	Unit-III- Computational chemistry	10	

**Learning objectives:**

The learner to be imparted with:

1. Knowledge of important terms in medicinal chemistry, factors affecting bioactivities, Basic pharmacokinetics, Physical and chemical parameters of drugs.
2. Drug discovery, design, and development.
3. Study of QSAR parameters, modern methods of drug design and synthesis, concept of prodrugs and soft drugs.
4. Basic principles of green chemistry, use of green reagents, solvent, green catalyst, solid state reagents, microwave assistant synthesis and ultrasound assisted reactions.

- Approach to solve chemical problems by simulating chemical systems (molecular, biological, materials) in order to provide reliable, accurate, and comprehensive information at an atomic level.

**Learning outcomes:**

On successful completion of this course students will be able to:

- Know the basic terms involved in medicinal chemistry, procedures involved in drug design.
- Learn the concepts of SAR and QSAR parameters on drug function and the concept of prodrugs.
- Summarize the twelve principles of green chemistry and application in synthetic organic chemistry.
- Learn the concepts of computational chemistry.

Units	Topics	Lectures
<b>UNIT I</b>	<b>Drug design, development and synthesis</b>	<b>10</b>
	<p><b>1.1 Introduction to quantitative structure activity relationship studies. QSAR parameters:</b> steric effects: The Taft equation; Methods used to correlate regression parameters with biological activity: Hantzsch analysis- A linear multiple regression analysis. [4L]</p> <p><b>1.2 Introduction to modern methods of drug design and synthesis</b> computer-aided molecular graphics-based drug design, drug design via enzyme inhibition (reversible and irreversible). [2L]</p> <p><b>1.3 Concept of prodrugs and soft drugs.</b> (a) Prodrugs: Prodrug design, types of prodrugs, functional groups in prodrugs, advantages of prodrug use. (b) Soft drugs: concept and properties. [2L]</p> <p><b>1.4 Synthesis and application of the following drugs:</b> Fluoxetine, zidovudine, methotrexate. Voriconazole mesylate, Oseltamivir phosphate. (synthesis at the end). [2L]</p>	
<b>UNIT II</b>	<b>Green chemistry</b>	<b>10</b>
	<p><b>2.1 Introduction, basic principles of green chemistry. Designing a green synthesis:</b> Green starting materials, green reagents, green solvents and reaction conditions, green catalysts. [1L]</p> <p><b>2.2 Use of the following in green synthesis with suitable examples:</b></p> <p>a) Green reagents: dimethyl carbonate, polymer supported reagents.</p> <p>b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts, nanocatalysts.</p> <p>c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide.</p> <p>d) Solid state reactions: solid phase synthesis, solid supported</p>	

	synthesis e) Microwave assisted synthesis: reactions in water, reactions in organic solvents, solvent free reactions. f) Ultrasound assisted reactions. [7L] <b>2.3 Comparison of traditional processes versus green processes</b> in the synthesis of ibuprofen, adipic acid, 4-aminodiphenylamine, p-bromotoluene and benzimidazole. [2L]	
<b>UNIT III</b>	<b>Computational Chemistry</b>	10
	3.1 Huckel molecular orbital theory for alternant and non-alternant hydrocarbons. 3.2 Variation principles. 3.3 Perturbation theory. 3.4 Ab initio methods	

**Justification:** Computational chemistry is new direction in field of research hence PGstudents are introduced with this topic.

#### Learner's space

1. Able to learn synthesis of drugs.
2. Knowledge about green catalysts, reagents, solvents, and their role in the synthesis.
3. Study of different methods in computational chemistry.

**Job oriented/Entrepreneurship development topics:** Drug design, synthesis and development, computational chemistry.

#### References:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of biochemistry 5<sup>th</sup> edition, W. H. Freeman and Company, NY., USA.
2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers.
3. Voet, D. and J. G. Voet (2004) Biochemistry, 3<sup>rd</sup> Edition, John Wiley & sons, Inc. USA.
4. K. Philippot and P. Serp, Nanomaterials in catalysis, 1<sup>st</sup> Edition. Edited by P. Serp and K. Philippot; 2013 Wiley-VCH Verlag GmbH & Co. KGaA.
5. D. Astruc, Nano materials and catalysis, Wiley-VCH Verlag GmbH & Co. KGaA, 2008, 1-48;
6. C. N. R. Roa, A. Muller and A. K. Cheetham, The chemistry of nanomaterials, Wiley-VCH Verlag GmbH & Co. KGaA, 2005, 1-11;
7. The organic chemistry of drug design and drug action, Richard B. Silverman, 2<sup>nd</sup> edition, Academic Press.
8. An introduction to medicinal chemistry-Graham L. Patrick, OUP Oxford, 2009.
9. Principles of medicinal chemistry (Vol. I and II)-S. S. Kadam, K. R. Mahadik and

K.G. Bothara, Nirali prakashan.

10. Bioorganic, bioinorganic and supramolecular chemistry, P.S. Kalsi and J. P. Kalsi. New Age International Publishers.
11. The organic chemistry of enzyme-catalysed reactions, Academic Press, By Richard B. Silverman.
12. Enzymes: practical introduction to structure, mechanism and data analysis, By Robert A. Copeland, Wiley-VCH, Inc.
13. The organic chemistry of biological pathways by John McMurry, Tadhg Begley by Robert and company publishers.
14. Bioorganic chemistry- A practical approach to enzyme action, H. Dugas and C. Penny. Springer Verlag, 1931.
15. Biochemistry: The chemical reactions in living cells, by E. Metzler. Academic Press.
16. Natural products chemistry and applications, Sujata V Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House.
17. Natural products, Volume- 2, By O. P. Agarwal.
18. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974.
19. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co.
20. Green chemistry: An introductory text, 2<sup>nd</sup> Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.
21. Organic synthesis in water. by Paul A. Grieco, Blackie.
22. New trends in green chemistry by V. K. Ahulwalia and M. Kidwai, 2<sup>nd</sup> edition, Anamaya Publishers, New Delhi.
23. An introduction to green chemistry, V. Kumar, Vishal Publishing Co.
24. Organic synthesis: Special techniques. V. K. Ahulwalia and Renu Aggarwal.
25. F. Jensen, Introduction to computational chemistry, 2<sup>nd</sup> edition, John Wiley & Sons Ltd.
26. C. J. Cramer, "Essentials of computational chemistry: Theories and Models".

#### **ICT Backup:**

1. <https://youtu.be/3oIQGJ4xdmg>
2. <https://youtu.be/P22YhwTEnJU>
3. <https://youtu.be/JGUYH-v7spI>
4. <https://youtu.be/uIFzewPhbAA>

#### **Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform-Swayam Drug discovery, design and development <a href="https://onlinecourses.nptel.ac.in/noc23_cy10/preview">https://onlinecourses.nptel.ac.in/noc23_cy10/preview</a>	12 weeks	50%	Free

**Paper IV- Intellectual Property Rights (Elective) (CH24305EL)**

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- IPR I	10	
2	Unit-II- IPR II	10	
3	Unit-III- IPR III	10	

**Learning objectives:**

The learner to be imparted with:

1. Knowledge of different types of intellectual property rights like Patents, Copy right, Trademarks, Geographical indicator etc.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Know the terms involved in IPR.
2. Distinguish and explain various forms of IPRs.
3. Do comparative study between patents and copyrights.
4. Recognise the importance of intellectual properties for an individual or business.
5. Elaborate on economic impact involved in IPRs.

Units	Topics	Lectures
<b>UNIT I</b>	<b>Intellectual Property Rights-I</b>	<b>10</b>
	<b>Introduction to Intellectual Property: [2L]</b> Historical Perspective, Different types of IP, Importance of protecting IP. <b>Patents: [4L]</b> Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. <b>Industrial Designs: [2L]</b> Definition, How to obtain, features, International design registration. <b>Copyrights: [2L]</b> Introduction, How to obtain, Differences from Patents.	

<b>UNIT II</b>	<b>Intellectual Property Rights-II</b>	<b>10</b>
	<p><b>Different International agreements:</b></p> <p><b>(a) World Trade Organization (WTO): [6L]</b></p> <p>(i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement</p> <p>(ii) General Agreement on Trade Related Services (GATS) Madrid Protocol.</p> <p>(iii) Berne Convention</p> <p>(iv) Budapest Treaty</p> <p><b>(b) Paris Convention [4L]</b> WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity.</p>	
<b>UNIT III</b>	<b>Intellectual Property Rights-III</b>	<b>10</b>
	<p><b>Trade Secrets: [2L]</b> Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.</p> <p><b>IP Infringement issue and enforcement: [2L]</b> Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.</p> <p><b>Economic Value of Intellectual Property: [2L]</b> Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.</p> <p><b>Trade Marks: [2L]</b> Introduction, How to obtain, Different types of marks- Collective marks, certification marks, service marks, trade names etc.</p> <p><b>Geographical Indications: [2L]</b> Definition, rules for registration, prevention of illegal exploitation, importance to India.</p>	

**Justification:**

Students will learn about important terms involved in intellectual property rights which will be important for future perspectives.

**Learner's space:**

Knowledge of intellectual property rights and terms involved in it.

**Job oriented/Entrepreneurship development topics:** Knowledge of patents, copyrights, trademarks, different international agreements, research methodology and various methods of scientific research.

**References:**

1. Law Relating to Intellectual Property by Sreenivasulu N S – 3rd Edition 2023

**ICT Backup:**

1. <https://youtu.be/FCcrrroZqn8>

2. <https://youtu.be/ngjdYGF2i00>

3. <https://youtu.be/92FROow3IIk>

**Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform- Udemy IPR <a href="https://www.udemy.com/course/certificate-course-ipr/">https://www.udemy.com/course/certificate-course-ipr/</a>	9 lectures 6h 55m	90%	Rs.449/-
2. Platform- Udemy IPR <a href="https://www.udemy.com/course/everything-about-ipr-intellectual-property-rights/">https://www.udemy.com/course/everything-about-ipr-intellectual-property-rights/</a>	15 lectures 10h 52m	80%	Rs.449/-

**Semester III Practicals**  
**Organic Chemistry Practical (Mandatory) (CH24307MM)**

**Learning objectives:**

1. To develop experimental skills of separation and identification of organic compounds.
2. The course aims to impart the knowledge of separation and qualitative analysis of ternary mixture of mono- and bifunctional organic compound using microscale technique.
3. Knowledge to prepare organic (g scale) involving purification by steam distillation / vacuum distillation or column chromatography.
4. The course aims to impart knowledge to the student regarding laboratory set up, safe handling of chemicals, workup procedures and effective disposal of organic waste.
5. Preparation of organic compounds in single steps.

**Learning outcomes:**

On completion of the course, students should be able to:

1. Carry out effective separation (pilot and bulk) of mixture of organic compounds.
2. Determine the functional group of the unknown compounds by systematic analysis in a semi-micro scale.
3. Design and carry out experiments, accurately record and analyse the results, calculate overall yield of the final product.
4. Purify organic compound by various methods.

Paper	Credit points
<p><b>Separation of a ternary mixture of organic compounds and identification including derivative preparations using micro-scale technique</b></p> <ol style="list-style-type: none"> <li>1. Separation of a ternary mixture (S-S-S, S-S-L, S-L-L and L-L-L) (for solid mixture: water insoluble/ soluble including carbohydrates) based upon differences in the physical and the chemical properties of the components.</li> <li>2. Identification of the two components (indicated by the examiner) using micro-scale technique.</li> <li>3. Preparation of derivatives (any one of separated compound). (Minimum 12 experiments)</li> </ol>	<p><b>02</b></p>

**Learner's space:**

1. Students can be able to separate ternary mixture based upon differences in the physical and the chemical properties of the components.
2. Can prepare derivative of separated compound.
3. Learner can plan the organic synthesis and know the effect of reaction parameters on organic synthesis.
4. Predict the possible mechanism and, expected spectral data (IR and NMR) of the starting material and final product.
5. Able to purify the product by using distillation methods.

**Job oriented/Entrepreneurship development topics:**

All the practicals will be helpful to students in their research work, synthetic laboratories and research laboratories for synthesis and identification of compounds.

All the practicals will be helpful to students in their research work, synthetic laboratories and research laboratories for synthesis and identification of compounds.

**ICT Backup:**

1. <https://www.youtube.com/watch?v=hB1ZanteY8Q>
2. <https://www.youtube.com/watch?v=h6Pcx2YDuCU>
3. <https://www.youtube.com/watch?v=taZc87rL18A&t=5s>
4. <https://www.youtube.com/watch?v=C-Z57zw-ob4&t=236s>
5. <https://www.youtube.com/watch?v=oRN9ExHEdcY>
6. <https://www.youtube.com/watch?v=UmWMIKJAdSk>

**Practical's in Single Step Synthesis (Elective) (CH24308EL)**

**Learning objectives:**

The course aims to impart to the student, knowledge of:

1. Preparation of organic (1.0 g scale) compound involving purification by steam distillation/vacuum distillation or column chromatography.
2. Laboratory set up, safe handling of chemicals, workup procedures and effective disposal of organic waste.
3. Preparation of organic compounds in two steps.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Carry out the synthesis of organic compounds by two step synthesis.
2. Purify the product by recrystallization, measure its mass or volume,
3. Check the purity by TLC, determine physical constant and calculate percentage yield.

<b>Paper</b>	<b>Credit points</b>
<p><b>Single step organic preparation (1.0 g scale) involving purification by Steam distillation / Vacuum distillation or Column chromatography.</b></p> <ol style="list-style-type: none"><li>1. Preparation of acetanilide from aniline and acetic acid using Zn dust. (Purification by column chromatography)</li><li>2. Preparation of 1-nitronaphthalene from naphthalene. (Purification by steam distillation)</li><li>3. Preparation of acetyl ferrocene from ferrocene. (Purification by column chromatography)</li><li>4. Preparation of 3-nitroaniline from 1,3-dinitrobenzene. (Purification by column chromatography)</li><li>5. Preparation of benzyl alcohol from benzaldehyde. (Purification by vacuum distillation).</li><li>6. Preparation of methyl salicylate from salicylic acid. (Purification by vacuum distillation).</li><li>7. Preparation of 4-methylacetophenone from toluene. (Purification by vacuum distillation).</li></ol> <p>Preparation of phenyl acetate from phenol. (Purification by vacuum distillation)</p> <ol style="list-style-type: none"><li>9. Preparation of 2-chlorotoluene from o-toluidine. (Purification by steam distillation)</li><li>10. Preparation of 4-nitrophenol from phenol. (Purification by steam distillation/ column chromatography)</li><li>11. Preparation of fluorenone from fluorene. (Purification by column chromatography)</li><li>12. Preparation of dimethyl phthalate from phthalic anhydride. (Purification by vacuum distillation)</li></ol> <p>Note:</p> <ol style="list-style-type: none"><li>1. Students are expected to know<ol style="list-style-type: none"><li>(i) The planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS</li><li>(ii) The possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.</li></ol></li><li>2. Students are expected to purify the product by Steam distillation / Vacuum distillation or Column chromatography, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.</li></ol>	<b>02</b>

**Justification:**

No change in practicals.

**Learner's space:**

1. Able to plan the synthesis of organic compound by two step method.
2. Knowledge about MSDS.
3. Predict the spectral data of starting material and final product.

**Job oriented/Entrepreneurship development topics:**

All the practicals help to develop skills required to work in industries as well as research-oriented organizations.

**ICT Backup:**

1. <https://www.youtube.com/watch?v=EsWPntN2oKg>
2. <https://www.youtube.com/watch?v=zcq8911DcKs>
3. <https://www.youtube.com/watch?v=B43mzwVThKw>
4. <https://www.youtube.com/watch?v=oaTO-5TCOHc>

**SEMESTER IV****Paper-I- Theoretical organic chemistry-II (CH24401MM)**

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- Physical organic chemistry	15	4
2	Unit-II- Supramolecules	15	
3	Unit-III- Stereochemistry-II	15	
4	Unit-IV- Asymmetric synthesis	15	

**Learning objectives:**

The learner to be imparted with:

1. Knowledge of various types of simple structures.
2. Understanding structural effects and reactivity equation, derivatives, effects.
3. Study of supramolecular chemistry.
4. Understand the determination of enantiomer and diastereomer composition, molecular dissymmetry and chiroptical properties and applications.
5. Detailed study of principles of asymmetric synthesis.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Learn about LFER in determination of organic reaction mechanism.
2. Apply the principles of supramolecular chemistry for extraction of compounds.
3. Discuss the principles of asymmetric synthesis.
4. Acquire knowledge about molecular dissymmetry and chiroptical properties involved in stereochemistry.

<b>UNIT I</b>	<b>Physical organic chemistry</b>	<b>15</b>
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	<p><b>1.1 Structural effects and reactivity:</b> Linear free energy relationship (LFER) in determination of organic reaction mechanism, The Hammett equation, substituent constants, theories of substituent effects, interpretation of <math>\sigma</math> values, reaction constants <math>\rho</math>, Yukawa-Tsuno equation. [7L]</p> <p><b>1.2</b> Uses of Hammett equation, deviations from Hammett equation. Dual parameter correlations, Inductive substituent constants. The Taft model, <math>\sigma_I</math> and <math>\sigma_R</math> scales, steric parameters <math>E_s</math> and <math>\beta</math>. Solvent effects, Okamoto-Brown equation, Swain-Scott equation, Edward and Ritchie correlations, Grunwald-Winstein equation, Dimroth's ET parameter, Solvatochromism Z-scale, Spectroscopic Correlations, Thermodynamic Implications. [8L]</p>	
<b>UNIT II</b>	<b>Supramolecular chemistry</b>	<b>15</b>
	<p><b>2.1</b> Principles of molecular associations and organizations as exemplified in biological macromolecules like nucleic acids, proteins, and enzymes. [3L]</p> <p><b>2.2 Synthetic molecular receptors:</b> receptors with molecular cleft, molecular tweezers, receptors with multiple hydrogen sites. [3L]</p> <p><b>2.3</b> Structures and properties of crown ethers, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins. Synthesis of crown ethers, cryptands and calixarenes. [5L]</p> <p><b>2.4</b> Molecular recognition and catalysis, molecular self-assembly. Supramolecular Polymers, Gels and Fibres. [4L]</p>	
<b>UNIT III</b>	<b>Stereochemistry- II</b>	<b>15</b>
	<p><b>3.1 Racemisation and resolution of racemates including conglomerates:</b> Mechanism of racemisation, methods of resolution: mechanical, chemical, kinetic and equilibrium asymmetric transformation and through inclusion compounds. [3L]</p> <p><b>3.2 Determination of enantiomer and diastereomer composition:</b> enzymatic method, chromatographic methods. Methods based on NMR spectroscopy: use of chiral derivatising agents (CDA), chiral solvating agents (CSA) and Lanthanide shift reagents (LSR). [3L]</p> <p><b>3.3</b> Correlative method for configurational assignment: chemical, optical rotation, and NMR spectroscopy. [4L]</p> <p><b>3.4 Molecular dissymmetry and chiroptical properties:</b> Linearly and circularly polarized light. Circular birefringence and circular dichroism. ORD and CD curves. Cotton effect and its applications. The octant rule and the axial <math>\alpha</math>-haloketone rule with applications. [5L]</p>	
<b>UNIT IV</b>	<b>Asymmetric synthesis</b>	<b>15</b>
	<p><b>4.1 Principles of asymmetric synthesis:</b> Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent, and catalyst-controlled reactions. [3L]</p> <p><b>4.2</b> Synthesis of L-DOPA [Knowles's Monsanto process]. Asymmetric reactions with mechanism: Aldol and related reactions,</p>	

	<p>Cram's rule, Felkin-Anh model, Sharpless enantioselective epoxidation, hydroxylation, aminohydroxylation, Diels-Alder reaction, reduction of prochiral carbonyl. [9L]</p> <p><b>4.3</b> Use of chiral auxiliaries in diastereoselective reductions, asymmetric amplification. Use of chiral BINOLs, BINAPs and chiral oxazolines asymmetric transformations. [3L]</p>	
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**Justification:**

No change in syllabus of paper I.

**Learner's space:**

1. Learn the structures and properties of supramolecules.
2. Know the concepts of molecular assembly, intermolecular bond in macromolecules and their effect in catalytic activity.
3. Analyse the properties of molecules by studying circular dichroism and optical rotatory dispersion.
4. Appreciate the importance of asymmetric synthesis, exemplified by Felkin-Anh model.

**Job oriented/Entrepreneurship development topics:** Supramolecular chemistry, stereochemistry, principles of asymmetric synthesis, structural effects, and reactivity.

**References:**

1. March's Advanced Organic Chemistry, Jerry March, 6<sup>th</sup> edition, 2007, John Wiley and sons.
2. A guide to mechanism in Organic Chemistry, 6<sup>th</sup> edition, 2009, Peter Sykes, Pearson education, New Delhi.
3. Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002).
4. Mechanism and theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.
5. Organic Reaction Mechanism, 4<sup>th</sup> edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.
6. Reaction Mechanism in Organic Chemistry, S. M. Mukherji, S. P. Singh, Macmillan Publishers, India.
7. Organic Chemistry, Part A and B, Fifth edition, 2007, Francis A. Carey and Richard J. Sundberg, Springer.
8. Carbenes, Nitrenes and Arynes. Von T. L. Gilchrist, C. W. Rees. Th. Nelson and Sons Ltd., London 1969.
9. Organic reactive intermediates, Samuel P. MacManus, Academic Press.
10. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1<sup>st</sup> Edition, Oxford University Press (2001).
11. Organic Chemistry, 7<sup>th</sup> Edition, R. T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.
12. Advanced Organic Chemistry: Reactions & Mechanisms, second edition, B. Miller and R. Prasad, Pearson.
13. Organic reactions & their mechanisms, third revised edition, P. S. Kalsi, New

Age International Publishers.

14. Organic Chemistry: Structure and Function, P. Volhardt and N. Schore, 5<sup>th</sup> Edition, 2012.
15. Organic Chemistry, W. G. Solomons, C. B. Fryhle, 9<sup>th</sup> Edition, Wiley India Pvt. Ltd., 2009.
16. Pericyclic Reactions, S. Sankararaman, Wiley VCH, 2005.
17. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011.
18. Pericyclic reactions, Ian Fleming, Oxford university press, 1999.
19. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
20. Organic chemistry, 8<sup>th</sup> edition, John McMurry 8.
21. Modern methods of Organic Synthesis, 4<sup>th</sup> Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004.
22. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books, 2006.
23. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman.
24. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3<sup>rd</sup> edition, New Age International Ltd.
25. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India edit.
26. Stereochemistry, P. S. Kalsi, 4<sup>th</sup> edition, New Age International Ltd.
27. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005.
28. Bioorganic, Bioinorganic and Supramolecular chemistry, P. S. Kalsi and J. P. Kalsi. New Age International Publishers.
29. Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.
30. Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.
31. Large ring compounds, J. A. Semlyen, Wiley-VCH, 1997.
32. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley Eastern.
33. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
34. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
35. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill.
36. Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
37. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
38. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A John Wiley and Sons, Ltd., Publication).

#### **ICT Backup:**

1. <https://youtube.com/playlist?list=PLi4x8U-JupGj02OI3kt5SFRFG40wGcuk>
2. <https://youtu.be/69rA29hjtT4>
3. <https://youtu.be/IIL9UwkCMfE>

#### **Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

Platform and link	Course duration	Similarity index	Tentative cost
<b>1. Platform-</b> Swayam Structure and stereochemistry of compounds <a href="https://onlinecourses.nptel.ac.in/noc23_cy23/preview">https://onlinecourses.nptel.ac.in/noc23_cy23/preview</a>	8 weeks	50%	Free

**Paper II- Synthetic organic chemistry and microscopy of surface chemistry (CH24402MM)**

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- Designing organic synthesis I	15	4
2	Unit-II- Designing organic Synthesis II	15	
3	Unit-III- Electro-organic chemistry and transition metals in organic synthesis	15	
4	Unit-IV- Microscopy of surface chemistry	15	

**Learning objectives:**

The learner to be imparted with:

1. Knowledge of various types of simple structures.
2. Study of retrosynthetic analysis and synthetic planning, Concept of umpolung of organic synthesis
3. Use of transition metals in the synthesis of organic compounds.
4. Applications of palladium in organic synthesis.
5. Detailed study of ESCA, Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM) and Transmission Electron Microscopy (TEM).

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Design the organic molecules by applying disconnection approach, name reactions in organic synthesis.
2. Propose a retrosynthetic strategy for organic compounds.
3. Learn the forward synthesis, starting material and steps involved in the synthesis of compounds.
4. Know the application of transition metals in the organic synthesis.
5. Analyse the concepts of microscopy of surface chemistry.

Units	Topics	Lectures
<b>UNIT I</b>	<b>Designing organic synthesis-I</b>	<b>15</b>

	<p><b>1.1 Protecting groups in Organic Synthesis:</b> Protection and deprotection of the hydroxyl, carbonyl, amino and carboxyl functional groups and its applications. [3L]</p> <p><b>1.2 Concept of umpolung (Reversal of polarity):</b> Generation of acyl anion equivalent using 1,3-dithianes, methyl thiomethyl sulfoxides, cyanide ions, cyanohydrin ethers, nitro compounds and vinylated ethers [3L]</p> <p><b>1.3 Introduction to Retrosynthetic analysis and synthetic planning:</b> Linear and convergent synthesis; Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group interconversions (FGI), functional group addition (FGA), functional group removal (FGR) importance of order of events in organic synthesis, one and two group C-X disconnections (1,1; 1,2; 1,3 difunctionalized compounds), selective organic transformations: chemoselectivity, regioselectivity, stereoselectivity, enantioselectivity. [9L]</p>	
<b>UNIT II</b>	<b>Designing organic synthesis-II</b>	<b>15</b>
	<p><b>2.1 General strategy:</b> choosing a disconnection-simplification, symmetry, high yielding steps, and recognisable starting material. [3L]</p> <p><b>2.2 One group C-C Disconnections:</b> Alcohols (including stereoselectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. [6L]</p> <p><b>2.3 Two group C-C Disconnections:</b> 1,2- 1,3- 1,4- 1,5- and 1,6-difunctionalized compounds, Diels-Alder reactions, <math>\alpha</math>, <math>\beta</math>-unsaturated compounds, control in carbonyl condensations, Michael addition and Robinson annelation. [6L]</p>	
<b>UNIT III</b>	<b>Electro-organic chemistry and transition metals in organic synthesis</b>	<b>15</b>
	<p><b>3.1 Electro-organic chemistry:</b> [7L]</p> <p>3.1.1 Introduction: Electrode potential, cell parameters, electrolyte, working electrode, choice of solvents, supporting electrolytes.</p> <p>3.1.2 Cathodic reduction: Reduction of alkyl halides, aldehydes, ketones, nitro compounds, olefins, arenes, electro-dimerization.</p> <p>3.1.3 Anodic oxidation: Oxidation of alkylbenzene, Kolbe reaction, Non-Kolbe oxidation, Shono oxidation.</p> <p><b>3.2 Introduction to basic concepts:</b> 18 electron rule, bonding in transition metal complexes, C-H activation, oxidative addition, reductive elimination, migratory insertion. [3L]</p> <p><b>3.3 Palladium in organic synthesis:</b> <math>\pi</math>-bonding of Pd with olefins, applications in C-C bond formation, carbonylation, alkene isomerisation, cross-coupling of organometallics and halides. Representative examples: Heck reaction, Suzuki-Miyaura coupling, Sonogashira reaction and Wacker oxidation. Heteroatom coupling for bond formation between aryl/vinyl groups and N, S, or P atoms. [5L]</p>	
<b>UNIT IV</b>	<b>Microscopy of surface chemistry</b>	<b>15</b>

	ESCA, Scanning Electron Microscopy (SEM), Atomic force microscopy (AFM) and Transmission Electron Microscopy (TEM): Instrumentation and applications.	
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**Justification:**

Students will learn about the applications of transition metals in the organic synthesis. Microscopy of surface chemistry is important characterization tool from research point of view. These methods have important applications in the various fields of research.

**Learner's space:**

1. Able to design organic synthesis.
2. Study of electro-organic chemistry and important name reactions.
3. Knowledge of transition metals used in the organic synthesis.
4. Detailed knowledge of microscopy of surface chemistry.

**Job oriented/Entrepreneurship development topics:** Designing organic synthesis, role of transition metals in organic synthesis, Instrumentation, and applications of various microscopic techniques like SEM, TEM, AFM etc.

**References:**

1. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5<sup>th</sup> Edition, Springer Verlag.
2. Modern Methods of Organic Synthesis, 4<sup>th</sup> Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.
3. Chem.Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis, S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam.
4. Organic Chemistry, Clayden Greeves Warren and Wothers, Oxford Press (2001).
5. Modern Organic Synthesis: An Introduction, G. S. Zweifel and M. H. Nantz, W.H. Freeman and Company, (2007).
6. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press (2002).
7. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon, 3<sup>rd</sup> Edn., Nelson Thornes
8. Organic Chemistry, 7<sup>th</sup> Edn, R. T. Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
9. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti & B. Czako (2005), Elsevier Academic Press.
10. Advanced Organic Chemistry: Reactions & Mechanisms, 2<sup>nd</sup> Edn., B. Miller & R. Prasad, Pearson.
11. Organic reactions and their mechanisms, 3<sup>rd</sup> revise edition, P. S. Kalsi, New Age International Publishers.
12. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004.
13. Name Reactions and Reagents in Organic Synthesis, 2<sup>nd</sup> Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience.
14. Name Reactions, Jie Jack Lie, 3<sup>rd</sup> Edn., Springer

15. Organic Electrochemistry, H. Lund, and M. Baizer, 3<sup>rd</sup> Edn., Marcel Dekker.
16. A Beginners' Guide to Scanning Electron Microscopy, Anwar Ul-Hamid, Springer.
17. A Practical Guide to Transmission Electron Microscopy, Zhiping Luo, Momentum Press.
18. An Introduction to Microscopy, Suzanne Bell, Keith Morris, CRC press.
19. Chemical Analysis Modern Instrumentation Methods and Techniques, Francis Rouessac and Annick Rouessac, Wiley.
20. Handbook of X-ray Photoelectron Spectroscopy, Jolm F. Moulder William F. Stickle Peter E. 'Sobol Kennetlf D. Bomben, Perkin-Elmer Corporation Physical Electronics Division.
21. Scanning Electron Microscopy and X-Ray Microanalysis, Joseph I. Goldstein Dale E. Newbury Joseph R. Michael Nicholas W.M. Ritchie John Henry J. Scott David C. Joy, Springer.
22. Scanning Probe Microscopy: Atomic Force Microscopy and Scanning Tunneling Microscopy, Bert Voigtlander, Springer.
23. X-Ray Photoelectron Spectroscopy, Paul Van Der Heide, Wiley.
24. Designing organic synthesis by Stuart Warren, John Wiley and Sons.

#### ICT Backup:

1. <https://youtu.be/2I5vmNkYTOk>
2. <https://youtu.be/qsrwpX3K8AI>
3. <https://youtu.be/DBiEc8KM1e0>

#### Pedagogy:

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

#### MOOC:

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform- UdeMy Material characterization techniques <a href="https://www.udemy.com/course/materials-characterization-techniques/">https://www.udemy.com/course/materials-characterization-techniques/</a>	14 lectures	60%	Rs.1999/-

### Paper III- Natural products and heterocyclic chemistry (Elective -I) (CH24403EL)

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- Natural products- III	15	4
2	Unit-II- Natural products- IV	15	
3	Unit-III- Heterocyclic- I	15	
4	Unit-IV- Heterocyclic -II	15	

**Learning objectives:**

The learner to be imparted with:

1. Knowledge of structure, classification, occurrence, biological role, and importance of steroids.
2. The knowledge of synthesis of different steroids.
3. Study of classification, sources, and biological importance of different vitamins.
4. Introduction, classification, and nomenclature of heterocyclic compounds of monocyclic (3-5) member and (5-6) member and synthesis of heterocyclic compounds.
5. Detailed study of various terpenoids.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Analyse biological roles of steroids, vitamins, terpenoids and antibiotics.
2. Learn the synthesis of natural products.
3. Apply the rules of IUPAC nomenclature of heterocyclic compounds.

<b>Units</b>	<b>Topics</b>	<b>Lectures</b>
<b>UNIT I</b>	<b>Natural products-III</b>	<b>15</b>
	1.1 Steroids: General structure, classification. Occurrence, biological role, important structural and stereochemical features of the following: corticosteroids, steroidal hormones, steroidal alkaloids, sterols and bile acids. [5L] 1.2 Synthesis of 16-DPA from cholesterol and plant sapogenin. [2L] 1.3 Synthesis of the following from 16-DPA: androsterone, testosterone, oestrone, oestriol, oestradiol and progesterone. [5L] 1.4 Synthesis of Cinerolone, Jasmolone, Allethrolone, Exaltone and Muscone. [3L]	
<b>UNIT II</b>	<b>Natural products-IV</b>	<b>15</b>

	<p>2.1 Vitamins: [5L]  Classification, sources, and biological importance of vitamin B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, folic acid, B<sub>12</sub>, C, D<sub>1</sub>, E (<math>\alpha</math>-tocopherol), K<sub>1</sub>, K<sub>2</sub>, H (<math>\beta</math>- biotin).  Synthesis of the following:  Vitamin A from <math>\beta</math>-ionone and bromoester moiety.  Vitamin B<sub>1</sub> including synthesis of pyrimidine and thiazole moieties  Vitamin B<sub>2</sub> from 3, 4-dimethylaniline and D (-) ribose  Vitamin B<sub>6</sub> from: 1) ethoxyacetylacetone and cyanoacetamide,  2) ethyl ester of N-formyl-DL-alanine (Harris synthesis)  Vitamin E (<math>\alpha</math>-tocopherol) from trimethylquinol and phytol bromide  Vitamin K<sub>1</sub> from 2-methyl-1, 4-naphthaquinone and phytol.</p> <p>2.2 Antibiotics: [6L]  Classification based on activity. Structure elucidation, spectral data of penicillin-G, cephalosporin-C and chloramphenicol. Synthesis of chloramphenicol (from benzaldehyde and <math>\beta</math>-nitroethanol) penicillin-G and phenoxymethylpenicillin from D-penicillamine and t-butyl phthalimide malonaldehyde (synthesis of D-penicillamine and t-butyl phthalimide malonaldehyde expected).</p> <p>2.3 Naturally occurring insecticides: Sources, structure, and biological properties of Pyrethrums (Pyrethrin I), Rotenoids (Rotenone). Synthesis of Pyrethrin I. [2L]</p> <p>2.4 Terpenoids: Occurrence, classification, structure elucidation, stereochemistry, spectral data, and synthesis of zingiberene. [2L]</p>	
<b>UNIT III</b>	<b>Heterocyclic compounds-I</b>	<b>15</b>
	Heterocyclic compounds: Introduction, classification, Nomenclature of heterocyclic compounds of monocyclic (3-6 membered) (Common, systematic (Hantzsch-Widman) and replacement nomenclature) Structure, reactivity, synthesis and reactions of Pyrazole, Imidazole, Oxazole, Isoxazole, Thiazole, Isothiazole, Pyridazines, Pyrimidine, Pyrazines and Oxazines.	
<b>UNIT IV</b>	<b>Heterocyclic compounds-II</b>	<b>15</b>
	Nomenclature of heterocyclic compounds of bicyclic/tricyclic (5-6 Membered) fused heterocycles (up to three hetero atoms). (Common, systematic (Hantzsch-Widman) and replacement nomenclature) Nucleophilic ring opening reactions of oxiranes, aziridines, oxetanes and azetidines. Structure, reactivity, synthesis, and reactions of coumarins, quinoxalines, cinnolines, indole, benzimidazoles, benzoxazoles, benzothiazoles, Purines and acridines.	

**Justification:**

No change in paper III.

**Learner's space:**

1. Learn about the importance of natural products and their synthesis.
2. Summarise the structure, reactivity, and synthesis some of the heterocyclic compounds.

**Job oriented/Entrepreneurship development topics:** Study of various natural products like steroids, vitamins, antibiotics etc., chemistry of heterocyclic

compounds.

**References:**

1. Natural product chemistry, A mechanistic, biosynthetic, and ecological approach, Kurt B. G. Torssell, Apotekarsocieteten – Swedish Pharmaceutical Press.
2. Natural products chemistry and applications, Sujata V. Bhat, B. A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
3. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974.
4. Natural Product Chemistry Vol. 1 and 2, K. Nakanishi J. Goto. S. Ito Majori and S. Nozoo, Academic Press, 1974.
5. Chemistry of natural products, V. K. Ahluwalia, Vishal Publishing Co. 2008.
6. Heterocyclic chemistry, 3<sup>rd</sup> edition, Thomas L. Gilchrist, Pearson Education, 2007.
7. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley Eastern Ltd., 1990.
8. Heterocyclic Chemistry, J. A. Joule, and G. F. Smith, ELBS, 2<sup>nd</sup> edition, 1982.
9. The Conformational Analysis of Heterocyclic Compounds, F. G. Riddell, Academic Press, 1980.

10. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. B. Benjamin, Inc., 1978.
11. An Introduction to the Chemistry of Heterocyclic Compounds, 2<sup>nd</sup> edition, B. M. Acheson, 1975.
12. Natural Products: Chemistry and Biological Significance Inter science, J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthrope and J. B. Harborne, Longman, Essex, 1994.
13. Organic Chemistry, Vol 2, I. L. Finar, ELBS, 6<sup>th</sup> edition, Pearson.
14. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
15. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
16. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M. P. Gupta and A. Marston, Harwood Academic Publishers.
17. Introduction to Flavonoids, B. A. Bohm, Harwood Academic Publishers, 1998.
18. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M. I. Choudhary, Harwood Academic Publishers, 1998.
19. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.
20. Total. Synthesis of Longifolene, J. Am. Chem. Soc., E. J. Corey, M. Ohno, R. B. Mitra, and P. A. Vatakencherry. 1964, 86, 478.
21. Total Synthesis of Longifolene, J. Am. Chem. Soc. 1961, 83, 1251.
22. The structure and total synthesis of 5-Vetivone, J. A. Marshall and P. C. Johnson, J. Org. Chem., 35, 192 (1970).
23. Total synthesis of spirovetivanes, J. Am. Chem. Soc. 1967, 89, 2750.
24. The Total Synthesis of Reserpine, Woodward, R. B.; Bader, F. E.; Bickel, H., Frey, A. J.; Kierstead, R. W. Tetrahedron 1958, 2, 1-57.
25. Total synthesis of Griseofulvin, Stork, G.; Tomasz, M. J. Am. Chem. Soc. 1962, 84, 310.
26. Synthesis of ( $\pm$ )-4-demethoxydaunomycinone, A. V. Rama Rao , G. Venkatswamy , S. M. Javeed M. , V. H. Deshpande, B. Ramamohan Rao, J. Org. Chem., 1983, 48 (9), 1552.
27. The Alkaloids, The fundamental Chemistry A biogenetic approach, Marcel Dekker Inc. New York, 1979.
28. Comprehensive Organic Chemistry by Barton and Ollis, Pergamon Press, Oxford, 1979.
29. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley, and Sons, 2002.
30. Biosynthesis of Natural Products, Mannitto Paolo, Ellis Horwoocl Limited, 1981.
31. Selected Organic synthesis, Ian Fleming, John Wiley, and Sons, 1973.
32. Total synthesis of Natural Products, J. Apsimon, John Wiley and Sons.
33. The Logic of Chemical Synthesis, E. J. Corey and Xue-Min Cheng, Wiley Inter science.
34. Classics in Total Synthesis, K. C. Nicolaou and E. J. Sorensen, Weinheim: VCH, 1996.
35. Spectroscopy of Organic compounds, P. S. Kalsi, New Age International Pub. Ltd. And Wiley Eastern Ltd., Second edition, 1995.
36. Applications of absorption spectroscopy of organic compounds, J. R. Dyer, Prentice Hall of India, 1987.

37. Spectrometric identification of organic compounds, R. M. Silverstein and others, John Wiley and Sons Inc., 5<sup>th</sup> ed., 1991.
38. Absorption spectroscopy of organic Molecules, V. M. Parikh, 1974.
39. Spectroscopic methods in organic chemistry, Williams and Fleming, Tata McGraw Hill, 4<sup>th</sup> ed, 1989.
40. Organic spectroscopy, William Kemp, ELBS, 3<sup>rd</sup> ed., 1987.
41. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4<sup>th</sup> ed., 2011.
42. Introduction to spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, 4<sup>th</sup> ed., 2009.
43. Organic spectroscopic structure determination: a problem-based learning approach Douglass F. Taber, Oxford University Press, 17- Sep-2007.
44. Organic Spectroscopy: Principles and applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004.
45. Alkaloids, V. K. Ahluwalia, Ane Books Pvt. Ltd.
46. Bio-transformations in organic chemistry, 5<sup>th</sup> Edition, Kurt Faber, Springer.
47. Structure determination of organic compounds, E. Pretsch, P. Bühlmann, C. Affolter, Springer.

**ICT Backup:**

1. <https://youtu.be/w5A0mqVEYBI>
2. <https://youtu.be/NyQlINA5bIA>

**Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

Platform and link	Course duration	Similarity index	Tentative cost
1. Platform- Udemy Natural products <a href="https://www.udemy.com/course/biomolecules-v/">https://www.udemy.com/course/biomolecules-v/</a>	16 lectures	40%	Rs. 999/-

**Paper – III- Bioorganic chemistry- I (Elective -II) (CH24403EL)**

Sr. No.	Units	Lectures	Credit Points
1	Unit-I- Biomolecules- I	15	4
2	Unit-II- Biomolecules- II	15	
3	Unit-III- Biomolecules- III	15	
4	Unit-IV- Biomolecules- IV	15	

**Learning objectives:**

The learner to be imparted with:

1. Knowledge of various types of amino acid, peptides, and proteins.

2. Concepts of nucleic acid, purine and pyrimidine bases and synthesis of oligosaccharide.
3. Knowledge of enzymes, factors affecting enzymes kinetic, mechanism of enzymes action.
4. Study of coenzymes, oxidative phosphorylation, chemiosmosis, rotary model for ATP synthesis and role of cytochrome in oxygen activation.
5. Detailed study of role of main enzymes involved in the synthesis, enzyme catalysed organic reactions, enzymes in organic synthesis, fermentation.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Know the concepts of proteins and nucleic acids.
2. Analyse the effect of physical parameters on the structure and function of nucleic acids.
3. Learn the various pathways towards the biosynthesis of important molecules.
4. Predict the pathways of synthesis biomolecules.

Units	Topics	Lectures
<b>UNIT I</b>	<b>Biomolecules-I</b>	<b>15</b>
	<p><b>1.1 Amino acids, peptides and proteins:</b> Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, <math>\alpha</math>- helix, <math>\beta</math>-sheets, super secondary structure. Tertiary structure of protein, folding and domain structure. Quaternary structure. [2L]</p> <p><b>1.2 Nucleic acids:</b> Structure and function of physiologically important nucleotides (c-AMP, ADP, ATP) and nucleic acids (DNA and RNA), replication, genetic code, protein biosynthesis, mutation. [3L]</p> <p><b>1.3 Structure:</b> Purine &amp; pyrimidine bases, ribose, deoxyribose, nucleosides and nucleotides (ATP, CTP, GTP, TTP, UTP) formation of polynucleotides strand with its shorthand representation. [3L]</p> <p><b>1.4 RNAs</b> (various types in prokaryotes and eukaryotes) m-RNA and r- RNA- general account, t- RNA-clover leaf model, Ribozymes.[2L]</p> <p><b>1.5 DNA:</b> Physical properties – Effect of heat on physical properties of DNA (Viscosity, buoyant density and UV absorption), Hypochromism, Hyperchromism and Denaturation of DNA. Reactions of nucleic acids (with DPA and Orcinol). [2L]</p> <p><b>1.6 Chemical synthesis of oligonucleotides:</b> Phosphodiester, Phosphotriester, Phosphoramidite and H- phosphonate methods including solid phase approach. [3L]</p>	

<b>UNIT II</b>	<b>Biomolecules-II</b>	<b>15</b>
	<p><b>2.1 Chemistry of enzymes:</b> Introduction, nomenclature, classes and general types of reactions catalysed by enzymes. Properties of enzymes: a) enzyme efficiency/ catalytic power b) enzyme specificity; Fischer's 'lock and key' and Koshland 'induced fit' hypothesis. Concept and identification of active site. [6L]</p> <p><b>2.2 Factors affecting enzyme kinetics:</b> Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and irreversible inhibition. [4L]</p> <p><b>2.3 Mechanism of enzyme action:</b> transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Mechanism of chymotrypsin catalysed hydrolysis of a peptide bond. [5L]</p>	
<b>UNIT III</b>	<b>Biomolecules – III</b>	<b>15</b>
	<p><b>3.1 Chemistry of coenzymes:</b> Structure, mechanism of action and bio-modelling studies of the following coenzymes: nicotinamide adenine dinucleotide, flavin adenine dinucleotide, thiamine pyrophosphate, pyridoxal phosphate, Vitamin B<sub>12</sub>, biotin, lipoic acid, Coenzyme A. [12L]</p> <p><b>3.2 Oxidative phosphorylation, chemiosmosis, rotary model for ATP synthesis and role of cytochrome in oxygen activation.</b> [3L]</p>	
<b>UNIT IV</b>	<b>Biomolecules – IV</b>	<b>15</b>
	<p><b>4.1</b> Role of main enzymes involved in the synthesis and breakdown of glycogen. [2L]</p> <p><b>4.2 Enzyme catalyzed organic reactions:</b> Hydrolysis, hydroxylation, oxidation and reduction. [6L]</p> <p><b>4.3 Enzymes in organic synthesis, Fermentation:</b> Production of drugs/drug intermediates by fermentation. Production of chiral hydroxy acids, vitamins, amino acids, β-lactam antibiotics. Synthesis of chemicals via microbial transformation, synthesis of L-ephedrine. Chemical processes with isolated enzymes in free form (hydrocyanation of m-phenoxybenzaldehyde) and immobilized form (production of 6- aminopenicillanic acid). [7L]</p>	

**Justification:**

No change in paper III contents.

**Learner's space:**

1. Know the importance of biomolecules in living beings.
2. Concepts of organic synthesis in biomolecules.
3. Knowledge of the role nucleic acids, amino acids, enzymes, etc. in organisms.

**Job oriented/Entrepreneurship development topics:** Amino acids, peptides and proteins, nucleic acids, enzyme catalyzed organic reactions.

**References:**

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5<sup>th</sup> Edition, W. H. Freeman and Company, NY., USA.
2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers.
3. Voet, D. and J. G. Voet (2004) Biochemistry, 3<sup>rd</sup> Edition, John Wiley & sons, Inc. USA.
4. K. Philippot and P. Serp, Nanomaterials in catalysis, 1<sup>st</sup> Edition. Edited by P. Serp and K. Philippot; 2013 Wiley –VCH Verlag GmbH & Co. KGaA.
5. C. N. R. Roa, A. Muller and A. K. Cheetham, The chemistry of n anomaterials, Wiley-VCH Verlag GmbH & Co. KGaA, 2005, 1-11;
6. The organic chemistry of drug design and drug action, Richard B. Silverman, 2<sup>nd</sup> edition, Academic Press.
7. Medicinal chemistry, D.Sriram and P. Yogeswari, 2<sup>nd</sup> edition, Pearson.
8. An introduction to drug design- S. S. Pandeya and J. R. Dimmock (New age international).
9. Burger's medicinal chemistry and drug discovery by Manfred E. Wolf.
10. Introduction to Medicinal chemistry by Graham Patrick.
11. Medicinal chemistry-William O. Foye.
12. T. B. of Organic medicinal and pharmaceutical chemistry-Wilson and Gisvold's (Ed. Robert F. Dorge).
13. Biochemistry, Dr. U. Satyanarayan and Dr. U. Chakrapani, Books and Allied (P) Ltd.
14. Bioorganic, bioinorganic and supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers.
15. The organic chemistry of enzyme-catalysed reactions, Academic Press, By Richard B. Silverman.
16. Bioorganic chemistry- A practical approach to enzyme action, H. Dugas and C. Penny. Springer Verlag, 1931.
17. Biochemistry: The chemical reactions in living cells, by E. Metzler. Academic Press.
18. Principles of biochemistry by Horton & others.
19. Bioorganic chemistry - A chemical approach to enzyme action by Herman Dugas and Christopher Penney.
20. Medicinal natural products: A biosynthetic approach by Paul M. Dewick. 3<sup>rd</sup> Edition, Wiley.
21. Natural product chemistry, a mechanistic, biosynthetic and ecological approach, Kurt

- B. G. Torssell, Apotekarsocieteten – Swedish pharmaceutical press.
22. Natural products chemistry and applications, Sujata V Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House.
  23. Natural products Volume- 2, By O. P. Agarwal.
  24. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974.
  25. Natural product chemistry Vol.1 and 2, K. Nakanishi J. Goto. S.Ito Majori and S. Nozoo, Academic Press, 1974.
  26. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co.
  27. Green chemistry: An Introductory Text, 2<sup>nd</sup> Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.
  28. Organic synthesis in water. By Paul A. Grieco, Blackie.
  29. Green chemistry, Theory and Practical, Paul T. Anastas and John C. Warner.
  30. New trends in green chemistry By V. K. Ahulwalia and M. Kidwai, 2nd edition, Anamaya Publishers, New Delhi.
  31. An introduction to green chemistry, V. Kumar, Vishal Publishing Co.
  32. Organic synthesis: Special techniques. V. K. Ahulwalia and Renu Aggarwal.

#### ICT Backup:

1. <https://youtu.be/z2OfqRHZ0B0>
2. <https://youtu.be/PK8Lf7N5gIA>
3. <https://youtu.be/d0E53RIsU9U>
4. <https://youtu.be/GkiW-nQQHfl>

#### Pedagogy:

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

Platform and link	Course duration	Similarity index	Tentative cost
<b>1. Platform-Swayam</b> Biomolecules <a href="https://onlinecourses.nptel.ac.in/noc23_cy03/preview">https://onlinecourses.nptel.ac.in/noc23_cy03/preview</a>	12 weeks	50%	Free
<b>2. Platform-Udemy</b> Biomolecules <a href="https://www.udemy.com/course/biomolecules-v/">https://www.udemy.com/course/biomolecules-v/</a>	5hr. 24 mins	40%	Rs. 999/-

**Semester IV: Practicals (Mandatory)**  
**Practicals in Two Step Synthesis**  
**(CH24405MM)**

**Learning objectives:**

The course aims to impart to the student, knowledge of:

1. Preparation of organic (1.0 g scale) compound involving purification by steam distillation/vacuum distillation or column chromatography.
2. Laboratory set up, safe handling of chemicals, workup procedures and effective disposal of organic waste.
3. Preparation of organic compounds in two steps.
4. Interpretation of spectral data of an organic compound using UV, IR, PMR, CMR and Mass spectroscopy.
5. Synthesis of various organic compounds and their applications under project evaluation.

**Learning outcomes:**

On successful completion of this course students will be able to:

1. Carry out the synthesis of organic compounds by two step synthesis.
2. Purify the product by recrystallization, measure its mass or volume,
3. Check the purity by TLC, determine physical constant and calculate percentage yield.
4. Elucidate the structure of provided organic compound.
5. Develop innovative approach for the synthesis of various organic products and their applications under project evaluation.

Paper	Credit points
<p><b>Two steps preparations</b></p> <ol style="list-style-type: none"> <li>1. Acetophenone → Acetophenone phenyl hydrazine → 2-phenyl indole.</li> <li>2. 2-naphthol → 1-phenyl azo-2-naphthol → 1-amino-2-naphthol.</li> <li>3. Cyclohexanone → cyclohexanone oxime → Caprolactum.</li> <li>4. Hydroquinone → hydroquinone diacetate → 2,5- dihydroxy acetophenone.</li> <li>5. 4-nitrotoluene → 4-nitrobenzoic acid → 4-aminobenzoic acid.</li> <li>6. o-nitroaniline → o-phenylene diamine → Benzimidazole.</li> <li>7. Benzophenone → benzophenone oxime → benzanilide.</li> <li>8. o-chlorobenzoic acid → N-phenyl anthranilic acid → acridone.</li> <li>9. Benzoin → benzil → benzilic acid.</li> <li>10. Phthalic acid → phthalimide → anthranilic acid.</li> <li>11. Resorcinol → 4-methyl-7-hydroxy coumarin → 4-methyl-7-acetoxy coumarin.</li> <li>12. Anthracene → anthraquinone → anthrone.</li> </ol> <p>(Minimum 8 experiments)</p>	<b>02</b>
<p>Note: 1. Students are expected to know</p> <ol style="list-style-type: none"> <li>(i) the planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS</li> <li>(ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.</li> </ol> <p>2. Students are expected to purify the product by recrystallization, measure its</p>	

mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.	
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**Practicals in Characterisation of Organic compound  
(CH24406MM)**

<b>Paper</b>	<b>Credit points</b>
<p><b>Combined spectral identification: Interpretation of spectral data of organic compounds (UV, IR, PMR, CMR and Mass spectra).</b> A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within 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. <b>(Minimum 8 different compounds).</b></p>	<b>02</b>

**Justification:** No change in Practicals.

**Learner's space:**

4. Able to plan the synthesis of organic compound by two step method.
5. Knowledge about MSDS.
6. Predict the spectral data of starting material and final product.
7. Improve practical knowledge and skills.
8. Enhance the problem-solving approach towards spectral data.

**Job oriented/Entrepreneurship development topics:**

All the practicals help to develop skills required to work in industries as well as research-oriented organizations.

All the practicals help to develop skills required to work in industries as well as research-oriented organizations.

**ICT Backup:**

1. <https://www.youtube.com/watch?v=EsWPntN2oKg>
2. <https://www.youtube.com/watch?v=zcq8911DcKs>
3. <https://www.youtube.com/watch?v=B43mzwVThKw>
4. <https://www.youtube.com/watch?v=oaTO-5TCOHc>
5. <https://www.youtube.com/watch?v=d8eK17I8XI0>
6. <https://www.youtube.com/watch?v=QLTOgXxJ4YA>
7. <https://www.youtube.com/watch?v=f2l8HuyN3iU>
8. <https://www.youtube.com/watch?v=GijsVLJy6sY>

**References:**

1. Comprehensive practical organic chemistry: Preparation and quantitative analysis- V. K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced practical organic chemistry- N. K. Vishnoi, 3<sup>rd</sup> edition, Vikas Publishing House Pvt. Ltd.
3. Systematic laboratory experiments in organic synthesis- A. Sethi, New Age International Publications.
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall

## Research Project (CH24404RP)

**Learner's space:**

1. Improve practical knowledge and skills.
2. Enhance the problem-solving approach towards spectral data

3. Learners will be able to study existing research papers and write research article.
4. Be aware of importance of lab-safety and safety protocols to be followed in laboratories.
5. Introduction to important terms involved in research methodology.
6. Get the knowledge regarding writing research articles.
7. Knowledge of transition metals used in the organic synthesis.
8. Detailed knowledge of microscopy of surface chemistry learner can plan the organic synthesis and know the effect of reaction parameters on organic synthesis.
9. Predict the possible mechanism and, expected spectral data (IR and NMR) of the starting material and final product.
10. Students can be able to separate binary mixture based upon differences in the physical and the chemical properties of the components.
11. Can prepare derivative of separated compound

**Syllabus of following universities referred:**

1. Savitribai Phule Pune University, Pune
2. Shivaji University, Kolhapur
3. University of Kolkata, Kolkata
4. Banaras Hindu University, Varanasi
5. Harvard University, Massachusetts, USA

**EVALUATION SCHEME:**

**EXAMINATION PATTERN**

External Exam: 60 marks

Internal Exam: 40 marks

**External Exam Paper Pattern:**

Total marks: 60

Duration: 2 hr. 30 mins

<b>1.</b>	<b>EXTERNAL ASSESSMENT FOR THEORY (Semester End Examination)</b>	<b>60 Marks</b>
	N.B. 1. All questions are compulsory 2. All questions carry	

	equal marks.	
Q.1	Based on Unit-I, II, III and IV A) Multiple choice questions B) Fill in the blanks C) Short questions (one or two line)	06 03 03
Q.2 A) OR B) P) OR Q)	Unit-I	06/07  06/05
Q.3 A) OR B) P) OR Q)	Unit-II	06/07  06/05
Q.4 A) OR B) P) OR Q)	Unit-III	06/07  06/05
Q.5 A) OR B) P) OR Q)	Unit-IV	06/07  06/05

<b>2.</b>	<b>EXTERNAL ASSESSMENT FOR THEORY PAPER IV (Semester End Examination)</b>	<b>60 Marks</b>
	N.B. 1. All questions are compulsory 2. All questions carry equal marks.	
Q.1	Based on Unit-I, II and III A) Multiple choice questions B) Fill in the blanks C) Short questions (one or two line)	06 03 03
Q.2 A) OR B) P) OR Q)	Unit-I	06/07  06/05

	Q.3 A) OR B) P) OR Q)	Unit-II	06/07  06/05
	Q.4 A) OR B) P) OR Q)	Unit-III	06/07  06/05
	Q.5	Unit-I to III (Solve any three out of six)	12

**Internal Exam Pattern: 40 marks**

<b>3.</b>	<b>INTERNAL ASSESSMENT</b>	<b>40 Marks</b>
2.1	One class test (Objectives/ Multiple Choice)	15 Marks
2.2	Assignment/ Project/ Presentation/Book or research paper Review	20 Marks
2.3	Active participation, Overall performance	05 Marks

**Evaluation Pattern for M.Sc. (PRACTICALS)**

<b>4.</b>	<b>EXTERNAL ASSESSMENT FOR PRACTICALS</b>	<b>200 Marks</b>
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Sem-III and Sem-IV	
Practical's (Each paper carries 100 marks. Distribution of marks is shown below.)	
Two experiment from each paper	80
Viva	10
Journal	10
Project evaluation	
Dissertation	80
Presentation	10
Viva	10
<b>TOTAL MARKS</b>	<b>100 + 200 = 300</b>

Practical examination of each paper for 100 marks will be held in two sessions. Students will have to perform two experiments in two sessions. Each session will be three and half hours. Students will have to perform the necessary experiments in each semester and all experiments should be reported in journal.

Passing Standard:

1. The student will have to secure a minimum of 40% marks in internal assessment as well as semester end examination per theory paper, for all the theory papers.
2. The college will conduct all the semester examinations of 100 marks per practical paper at the end of each semester. The student will have to secure a minimum of 40% marks in the examination per practical paper, for all the above practical papers.

