



Rayat Shikshan Sanstha's
Sadguru Gadge Maharaj College, Karad
(Empowered Autonomous College)
Affiliated to Shivaji University, Kolhapur.

Accredited 'A+' Grade' with CGPA 3.63 by NAAC

ISO 9001-2015 Certified, RUSA Beneficiary & NAAC Designated Mentor College

Revised Syllabus as per NEP-2020

For

M. Sc. Part-II

Organic Chemistry

Syllabus to be implemented from

June, 2024 onwards.

Rayat Shikshan Sanstha's
Sadguru Gadge Maharaj College, Karad
(Empowered Autonomous College)
Affiliated to Shivaji University, Kolhapur
Revised Syllabus for the Master of Science in Chemistry(As per NEP - 2020)
Applicable from the Academic Year 2024–25

Name of Program: M.Sc. Organic Chemistry

M. Sc. Organic Chemistry, a post-graduate degree program of the Sadguru Gadge Maharaj College, Karad affiliated to Shivaji University, Kolhapur is one of the best in the country because its curriculum involves most advanced topics like Organic reaction mechanisms, advanced spectroscopic methods, Advanced synthetic methods, Drug and Heterocycles, Theoretical Organic Chemistry, Stereochemistry, Chemistry of Natural Products, Applied organic chemistry, etc. and the practical training based on these advanced topics required to understand problems of the present time. Successful students of this course are capable of doing independent research work not only in relevant world-class laboratories but also in R&D sectors and in quality teaching institutes.

1. Program Outcomes (POs)

Program Outcomes (POs)

- PO1.** Students will be able to acquire in-depth knowledge about fundamental and applied organic chemistry concepts.
- PO2.** Students will be able to solve various problems by identifying the essential parts of a problem, formulating a strategy for solving the problem, applying appropriate techniques to arrive at a solution, testing the precision and accuracy of the solution, and interpreting the results.
- PO3.** Students will be able to acquire domain-specific knowledge and technical skills needed for employment in industries, and teaching fields and pursue research.
- PO4.** Students will be able to apply the fundamental knowledge to address the cross-cutting issues such as sustainable development.
- PO5.** Students will get perfect insight into organic chemistry research ethics for production of quality research.

PO6. Students will be able to communicate effectively i. e. being able to comprehend and write effective reports, make effective presentations and documentation and express the subject through technical writing and oral presentation.

2. Program Specific Outcomes (PSOs)

PSO1: The students will be able to get global level research opportunities to pursue Ph.D. programme, targeted approach of competitive Exams such as CSIR-NET/GATE/SET, discipline specific competitive exams conducted by service commission, etc.

PSO2: The students will be able to get employment opportunities in various industries like petrochemicals, metallurgical, materials and pharmaceutical, etc.

PSO3: Understands the background of Inorganic reaction mechanisms, complex chemical structures, and instrumental methods of chemical analysis, separation techniques and analytical methods of general purpose.

PSO4: Gains complete knowledge about all fundamental aspects of all the elements of chemistry.

- ❖ **Title:** M.Sc. Chemistry
- ❖ **Faculty:** Faculty of Science and Technology.
- ❖ **Year of Implementation:** For M. Sc. I (Semester I and Semester II): From July 2023 and for M. Sc. II (Semester III and Semester IV): From June 2024.

3. Framework of NEP 2.0 as per NEP-2020 for M. Sc. Degree in Organic Chemistry

M.Sc.-I (NEP 2023-24) (Level-6)					
Sem-I					PG Diploma after 3- year Degree
Sr. No.	Basket	Code	Subject	Credits	
1	Major	MJ-MCTO23-101	Organic Chemistry-I	04	
2	Major	MJ-MCTO23-102	Inorganic Chemistry-I	04	
3	Elective	EP-MCTO23-103	Physical Chemistry-I	04	
		EA-MCTO23-103	Analytical Chemistry-I	04	
		EI-MCTO23-103	Inorganic Chemistry-II	04	
		EO-MCTO23-103	Organic Chemistry-II	04	
4	RM	RM-MCTO23-104	Research Methodology	04	
5	Lab-I	MJ-MCPO23-105	Chemistry Practical Paper-I	04	
6	Lab-II	MJ-MCPO23-106	Chemistry Practical Paper-II	02	
Total				22	
Sem-II					
Sr. No.	Basket	Code	Subject	Credits	
1	Major	MJ-MCTO23-201	Physical Chemistry-II	04	
2	Major	MJ-MCTO23-202	Analytical Chemistry-II	04	
3	Elective	EO-MCTO23-203	Organic Chemistry-III	04	
		EP-MCTO23-203	Physical Chemistry-III	04	
		EA-MCTO23-203	Analytical Chemistry-III	04	
		EI-MCTO23-203	Inorganic Chemistry-III	04	
4	FP	FP-MCPO23-204	Field Project	04	
5	Lab-III	MJ-MCPO23-205	Chemistry Practical Paper-III	04	
6	Lab-IV	MJ-MCPO23-206	Chemistry Practical Paper-IV	02	
Total				22	

M.Sc. II Sem III (NEP 2023-24) (Level-6.5)					
Sr. No.	Basket	Code	Subject	Credits	Degree
1	Major	MJ-MCTO23-301	Organic Reaction Mechanism	04	PG Degree after 3-years or PG degree after 4-years UG (Master of Science)
2	Major	MJ-MCTO23-302	Advanced Spectroscopic methods	04	
3	Major	MJ-MCTO23-303	Advanced Synthetic methods	04	
4	Elective	EO-MCTO23-304	Drug and Heterocycles	04	
		EA-MCTA23-304	Environmental Chemical Analysis and Control		
5	RP	RP-MCPO23-305	Research Project	04	
6	Lab-V	MJ-MCPO23-306	Practical Course	02	
Total				22	
Sem IV					
Sr. No.	Basket	Code	Subject	Credits	Degree
1	Major	MJ-MCTO23-401	Theoretical Organic Chemistry	04	PG Degree after 3-years or PG degree after 4-years UG (Master of Science) All practical and projects will be discipline-specific i.e. Organic Chemistry oriented
2	Major	MJ-MCTO23-402	Stereochemistry	04	
3	Major	MJ-MCTO23-403	Chemistry of Natural Products	04	
4	Elective	EO-MCTO23-404	Applied Organic Chemistry	04	
		EA-MCTA23-404	Applied Analytical Chemistry		
5	Research Project	RP- MCPO23-405	Research Project	06	
Total				22	

4. Detailed Syllabus

M. Sc. II (Sem III) Organic Chemistry

MJ-MCTO23-301: Organic Reaction Mechanism

UNIT-I: Methods of determining reaction mechanism **15 hrs.**

- (A) Kinetic Methods:** Order and Molecularity, Methods of following reaction rates, Types of reactions: 1st, 2nd, and 3rd order reactions, Reversible, Consecutive, and Parallel reactions. Energy of Activation, Entropy of Activation, Effect of Ionic strength, Solvent effect, and Kinetic isotopic effect
- (B) Non-Kinetic Methods:** Identification of reaction products, Testing of the possible intermediates, Trapping of the intermediates, Isotopic labeling, Reaction catalysis, Cross-over experiments, Stereochemical studies, and Use of physical properties. Hammett and Taft equations.

UNIT-II: Pericyclic reactions **15 hrs.**

Molecular orbital symmetry, Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system, Classification of pericyclic reaction, Woodward-Hoffman correlation diagrams, FMO and PMO approach, Electrocyclic reactions, Conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl systems, Cycloaddition, and supra and antarafacial additions, $4n$ and $4n+2$ systems, $2+2$ additions of ketenes, 1,3-dipolar cycloaddition and Chelotropic reactions, Sigmatropic rearrangement, supra and antarafacial shifts of H, Sigmatropic shifts involving carbon moieties, (3,3) and (5,5) sigmatropic rearrangement and Claisen and Cope and Aza Cope rearrangement, Ene reaction.

UNIT-III: Study of the intermediate and name reactions **15 hrs.**

- (A) Ylides:** Nitrogen, Sulfur and Phosphorous ylides: Synthesis and applications in organic synthesis.
- (B) Name Reactions:** Alkyne metathesis reaction, Weinreb ketone synthesis, Petasis reaction, Henry reaction, Corey Kim oxidation. Reactions of carboxylic acids and esters.

UNIT-IV: Free radical reactions **15 hrs.**

Types of free radical reactions, Detection by ESR, Mechanism of free radical substitution, Neighboring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in attacking radicals. The effect of solvent on reactivity. Allylic halogenation (NBS), Oxidation of aldehydes to carboxylic acids, Auto-oxidation, Coupling of alkynes, Arylation of aromatic compounds by diazonium salt, Sandmeyer's reaction, Hunsdiecker reaction.

Reference Books:

1. A guide book to mechanism in organic chemistry (orient- Longmans)- Peter Sykes
2. Organic Reaction Mechanism (Benjumin)- R. Breslow
3. Mechanism and structure in Organic Chemistry (Holt Reinhartwinston)- B. S. Gould
4. Organic chemistry (McGraw Hill)- Hendrikson, cram and Hammond
5. Basic principles of organic chemistry (Benjamin) J. D. Roberts and M. C. Caeserio.
6. Reactive intermediates in organic chemistry, (J. Wiley) N. S. Issacs.
7. Organic reaction mechanism (McGraw Hill) R. K. Bansal
8. Fundamentals of photochemistry K. K. Rohtagi- Mukherji Wiley- Eastern
9. Essentials of molecular photochemistry, A. Gilbert and J. Baggott. Blackwell Scientific Publication.
10. Molecular photochemistry, N.J. Urro, W. A. Benjamin
11. Introductory photochemistry. Cox and T. Camp McGraw -Hill
12. Photochemistry R.P. Kundall and A. Gilbert. Thomson Nelson.
13. Strategic applications of named reactions in organic synthesis by Laszlo Kurti and Barbara Czako.
14. Organic photochemistry J. Coxon and B. Hallon Cambridge University press.

Course Outcomes (COs):

CO No. On completion of the course, students will be able to:

- CO1 Adopt the knowledge about the pathway and determine reaction rates using kinetic and non-kinetic methods. This involves steps such as reaction rate determination, order and molecularity, testing and trapping of intermediates, stereochemistry, and the Hammet-Taft equation.
- CO2 Familiarize with the concept of Pericyclic reactions, Woodward-Hoffmann correlation diagrams, and the Frontier Molecular Orbital (FMO) and Molecular Orbital (PMO) approaches. Understand conrotatory and disrotatory motion, and be able to identify reactions as $4n$, $4n+2$, and $2+2$ addition of ketenes. Additionally, learn about sigmatropic shifts (3,3) and (5,5), Claisen and Cope rearrangements, and Aza-Cope rearrangement.
- CO3 Learn about the mechanisms, stereochemistry, migratory aptitude, and applications of different name reactions such as Dienone-phenol, Favorskii, Smiles, Brooke, Neber, Stevens, and Sommelet-Houser rearrangement reactions.
- CO4 Adapt the knowledge about photochemistry – photochemical reactions, their types, and laws of photochemistry. Also, know quenching and chemiluminescence.

MJ-MCTO23-302: Advanced Spectroscopic methods

UNIT-I: Study of Ultraviolet and IR Spectroscopy

15 hrs.

(A) Ultraviolet Spectroscopy:

(5)

Woodward-Fisher rules for conjugated dienes and carbonyl compounds, Calculation of λ_{max} of conjugated dienes and carbonyl compounds. Ultraviolet spectra of aromatic and heterocyclic compounds, Steric effect in biphenyls.

(B) IR Spectroscopy:

(10)

Characteristic vibrational frequencies of (i) alkanes, (ii) alkenes, (iii) alkynes, (iv) aromatic compounds, (v) alcohols, (vi) ethers, (vii) phenols, (viii) amines. Detailed study of vibrational frequencies of carbonyl compounds; (i) ketones, (ii) aldehydes (iii) esters (iv) amides (v) acids (vi) anhydrides (vii) lactones (viii) lactams, and (ix) conjugated carbonyl compounds. Effect of hydrogen bonding and solvent effect on vibrational frequencies, Overtones, combination bands, and Fermi resonance, FT-IR of gaseous; solids and polymeric materials.

UNIT-II: NMR Spectroscopy

15 hrs.

General introduction and definition; chemical shift, spin-spin interaction, shielding mechanism of measurement, Chemical shift values, and correlation for protons bonded to (a) carbons: aliphatic, olefinic, aldehydic, and aromatic and (b) other nuclei: alcohols, phenols, enols, acids, amines, amides and mercaptans, Chemical exchange; effect of deuteration, Complex spin-spin interaction (first order spectra) between (i) two (ii) three (iv) four and (v) five nuclei, Virtual coupling, Stereochemistry; hindered rotation, Karplus curve variation of coupling constant with dihedral angle, Simplification: Simplification of complex spectra, nuclear magnetic double resonance, shift reagent, solvent effect. Fourier transform technique, Nuclear overhauser effect [NOE], NMR of F, and P nuclei.

UNIT-III: Mass Spectrometry

15 hrs.

Introduction of MS, Ionization methods; (i) EI, (ii) CI, (iii) FD (iv) FAB, and (v) MALDI-TOF, Factors affecting on fragmentation, Ion analysis, Ion abundance. Molecular ion peak, Metastable peak, McLafferty rearrangement, Nitrogen rule. Mass spectral fragmentation of organic compounds; (i) hydrocarbons (aliphatic and aromatic), (ii), carbonyls (aldehydes, ketones, acids, acid chlorides, esters, amides), (iii) halogen compounds (iv) amines, (iv) nitro compounds, High-resolution mass spectrometry (HRMS).

UNIT-IV: Study of ^{13}C NMR and Combined problems**15 hrs.****(A) Carbon-13 NMR Spectroscopy:****(7)**

General considerations; chemical shift; aliphatic, olefinic, alkyne, aromatic, heteroaromatic, and carbonyl compounds, problems associated with ^{13}C , FT-NMR, proton decoupled off-resonance.

(B) Structural Problems:**(8)**

Structural problems based on combined spectroscopic techniques (including reaction sequences)

Reference Books:

1. V.M. Parikh, Application spectroscopy of organic molecules. (Mehta)
2. D.W. Williams and Flemming, Spectroscopic methods of organic compound.
3. Silverstein and Basslar, Spectroscopic identification of organic compounds V.M. Parikh
ORPTION SPECTROSCOPY OF ORGANIC MOLECULES (J. Wiley)
4. P.S. Kalsi Spectroscope of organic compounds (New age publisher)
5. J.R. Dyer. Application of absorption spectroscopy of organic compounds.
6. Jackman and Sterneil, Application of NMR spectroscopy
7. Nuclear magnetic resonance. J.D. Roberts (J. Wiley)
8. Theory and application of U.V. Jafee and Orchin.
9. Mass spectroscopy K. Benjamin.
10. The mass spectra of organic molecules. Beynon J H.
11. Interpretation of carbon 13 NMR Wehli F.W, Marchand A. P. (J. Wiley)
12. Organic Spectroscopy W. Kemp, ELBS
13. Instrumental methods of analysis CBS. Willard Merritt and Dean.
14. Mass Spectroscopy. Das and Jame
15. Organic structural spectroscopy: J. B. Lambert, S. Gronert, H. F. Shurvell, D. Lightneli,
R. G. Cooks (Prentice Hall 2nd edition).

Course Outcomes (COs):

CO No. On completion of the course, students will be able to:

- CO1 Learn about the principles and theory behind UV and IR spectroscopy, including molecular vibrations due to IR radiation absorption and electronic excitations from UV radiation absorption. This will help students identify unknown organic compound structures and recognize functional groups such as alcohol, aldehyde, ketone, ester, and aromatic compounds. They will also study overtones, combination bands, and Fermi resonance in FT-IR spectroscopy.
- CO2 Recap proton NMR spectroscopy, factors affecting coupling constants, analyze first-order spectra, simplify complex spectra, understand second-order spectra, effect of deuteration, and spectra of Homotopic, Enantiotopic, and Diastereotopic systems. Also, learn about the Advanced NMR technique, Fourier transform technique, Nuclear Overhauser Effect (NOE), COSEY, NOSEY, and resonance of F^{19} and P^{31} nuclei.
- CO3 Learn about ion production methods (EI, CI, FD, and FAB) and factors affecting fragmentation analysis. Also understand mass spectral fragmentation of functional groups (e.g., aldehydes, ketones, esters, alcohols) to solve mass spectroscopy problems.
- CO4 Understand the concept of C^{13} NMR spectroscopy – chemical shift values of alkanes, alkenes, alkynes, aromatic compounds, carbonyl and heterocyclic compounds. Also learn this advanced C^{13} technique – NOE, DEPT, HETCOR and heteronuclear coupling. They will become confident to solve the problems on C^{13} NMR.

MJ-MCTO23-303: Advanced Synthetic methods

UNIT-I: Disconnection Approach

15 hrs.

- (a) Terms involved in retrosynthesis; synthons, synthetic equivalents, disconnection approach, functional group interconversions.
- (b) Importance of the order of events in organic synthesis
- (c) Chemoselectivity, Regioselectivity, and Stereoselectivity, Protecting groups,
- (d) One group C-X and two group disconnections in (i) 1, 2, (ii) 1, 3 (iii) 1, 4, and (iv) 1, 5-difunctional compounds,
- (e) Retrosynthesis of (i) alkanes (ii) alkene, (iii) acetylenes, (iv) nitro (v) alcohols (vi) carbonyl compounds, (vii) amines, (viii) aromatic heterocycles (ix) 3, 4, 5 and 6 membered rings.
- (f) Reversal of polarity (Umpolung).
- (g) Use of Diels-Alder reaction, Michael addition, and Robinson annulation in retrosynthesis.

UNIT-II: Applications of the following in organic synthesis

15 hrs.

- (A) **Reagents:** Lithium diisopropylamide(LDA) Dicyclohexyl carbodiimide(DCC), lead tetraacetate, PPA, Diazomethane, ozone, phase transfer catalyst, Selenium dioxide, Dess-Martin periodinane, and iodoisobenzyl diacetate, periodic acid
- (B) **Reactions:** Woodward-Prevost hydroxylation, Barton and Shapiro reaction, Hoffmann-Löffler-Fretag, Peterson synthesis, Olefin metathesis using Grub's catalysts.

UNIT-III: Applications of metals and ligands in organic synthesis

15 hrs.

- (A) Applications of metals in organic synthesis (7)
 - (i) Ti, (ii) Ce, (iii) Tl and (iv) Si
- (B) Applications of ligands in organic synthesis: Synthesis and Applications (8)
 - (i) Phosphines, (ii) N-heterocyclic carbenes (NHC), and (iii) Oxazoline

UNIT-IV: Applications of the following methods in organic synthesis

15 hrs.

- (a) Synthesis and applications of Merrifield resin
- (b) Electro-organic synthesis
- (c) Enzyme catalyzed reaction
- (d) Solvent free synthesis
- (e) Multicomponent reactions
- (f) Microwave techniques and their applications
- (g) Ultrasound techniques and their applications
- (h) Mechanochemical synthesis

Reference Books:

1. Designing of organic synthesis. S. Warren
2. Organic synthesis J. Fuhrhop & G. Penzlin. (2nd ed.)
3. Some modern methods of organic synthesis. Carruthers:
4. Modern synthetic reaction. H. O. House
5. Reagent in organic synthesis. Fieser & Fieser
6. Principle of organic synthesis. R. O. C. Norman
7. Advanced organic Chemistry. Carey & Sundberg
8. Organic synthesis. P. E. Realand:
9. Comprehensive organic Chemistry. Bartan and Ollis:
10. Organic reactions. R. Adams:
11. Advances in organometallic Chemistry. Stone & West:
12. Transition metal intermediate in organic synthesis. C. W. Bird:
13. Organometallic in organic synthesis. Swan & black:
14. Synthesis of prostaglandins. A. Mitra:
15. Total synthesis of natural products. John Apsimon:
16. Phosphorus ligands in homogeneous catalysis: Design and synthesis by Paul C. J. Kamer.
17. Phosphorus ligands effect in homogeneous catalysis and rational catalyst design by Jason A. Gillespie and Erik Zuidema. Polymers as aid in organic synthesis. M. K. Mathur, C. K. Narang & R. E. Williams:
18. Polymer-supported reaction in organic synthesis. P. Hodge & D. C. Sherrington:
19. Enzyme catalyzed reactions. J. Gray:
20. Electroorganic Chemistry. T. Shona:
21. Phase transfer catalyst in organic synthesis. Weber & Gokel

Course Outcomes (COs):

CO No.	On completion of the course, students will be able to:
CO1	Understand the concept of the disconnection approach through the introduction of synthons, synthetic equivalents, and functional group interconversions. Also, understand retrosynthesis of difunctional compounds. Importance of the order of reaction in organic synthesis. They will learn Diel's Alder reaction, Michael addition, Robinson annulation, and what is meant by Umpolung reaction.
CO2	Study the applications of different reagents in chemical reactions and also study of Woodward – Prevost hydroxylation, Barton and Shapiro reaction as well as Grub's catalysis.
CO3	Learn how the different metals and ligands in organic chemistry.
CO4	Learn the new concept of supramolecular chemistry, advanced synthetic methods by using microwave ovens, ultrasound waves, using enzymes, electro-organic synthesis, use of multicomponent reactions as well as the use of Ionic liquids in chemical reactions.

Major Electives (Choose any One)

M.Sc. II, SEM-III

Students of Organic/Analytical Chemistry shall choose any one of the following elective papers.

EO-MCTO23-304: Drug and Heterocycles

Part- A: DRUGS

UNIT-I: Drug Design and Antibiotics	15 hrs.
A. Drug Design	(10)
Procedures followed in drug design, factors affecting the development of new drugs , concepts of prodrugs and soft drugs, Isosterism, bioisosterism , Theories of drug activity, Quantitative structure activity relationship, QSAR theory, Concepts of drug receptors.	
B. Study of Antibiotics	(5)
(i) Classification of antibiotics, (ii) Preparation of semi synthetic penicillin, (iii) Penicillin G, (iv) Penicillin V, (v) Conversion of penicillin into cephalosporin.	

UNIT-II: Study of the Following Drugs**15 hrs.**

- a) **Antimalerials:** Trimethoprim, Amodiaquine
- b) **Analgesic & Antipyretics:** Meperidine, Aminopyrine, Diflunisal
- c) **Anti-inflammatory:** Oxyphenylbutazone, Indomethacin
- d) **Antitubercular & antileprotic:** Dapsone, Pyrazinamide, Ethionamide
- e) **Anaesthetics:** Lidocaine, Thiopental
- f) **Antihistamines:** Cyproheptadine, Cetirizine
- g) **Psychoactive:** Ethiosuximide, Glutethimide
- h) **Antiinfective:** Grisefulvin, norfloxacin
- i) **Cardiovascular:** Warfarim, Clofibrate, Quinidine, Methyldopa, Atenolol
- j) **Anti-neoplastic:** Recent development in cancer chemotherapy. Hormones and natural products. Synthesis of (i) Mechloreaethamine, (ii) Cyclophosphamide, (iii) Mephalan, (iv) Uracils, (v) Mustards.
- k) **Anti-AIDS:** General study

Part-B: HETEROCYCLES**UNIT-III: Study of following heterocycles****15 hrs.**

- A) Small ring heterocycles: (5)**
3 and 4 membered heterocycles: Synthesis and reactions of (i) aziridines, (ii) oxiranes, (iii) thiranes, and (iv) azetidines.
- B) Six membered heterocycles with one heteroatom: (5)**
Synthesis and reactions of (i) pyrilium salts, (ii) pyrones, (iii) coumarins, (iv) chromones.
- C) Six membered heterocycles with two and more heteroatoms: (5)**
Synthesis and reactions of (i) diazines (ii) triazines

UNIT-IV: Study of following heterocycles**15 hrs.**

- A) Benzofused five membered heterocycles: (7)**
Synthesis and reactions of (i) benzopyrroles, (ii) benzofurans and (iii) benzothiophene
- B) Benzofused heterocycles with two heteroatoms: (8)**
Synthesis and reactions of
(j) benzimidazole, (ii) benzthiazole and (iii) benzoxazole

Reference Books:

1. Medicinal Chemistry. Burger
2. Medicinal Chemistry A. Kar. (Wiley East)
3. Principals of medicinal chemistry. W. O. Foye:
4. Text book of organic medical and pharmaceutical chemistry. Wilson, Gisvold & Dorque:
5. Pharmaceutical manufacturing encyclopedia.
6. D. Sriram, P. Yogeswari: Medicinal Chemistry
7. An introduction to chemistry of heterocyclic compounds. R. M. Acheson :(Interscience).
8. Heterocyclic chemistry. Joule & Smith: (Van Nostrand).
9. Heterocyclic chemistry. R. K. Bansal: (Wiley E).
10. Principals of modern heterocyclic chemistry. L. A. Paquette:
11. The structure and reactions of heterocyclic compounds. M. H. Palmer:
12. Advances in Heterocyclic chemistry. A. R. Katritzky: (A.P.).
13. Organic chemistry (Vol. 1 & 2) Finar.
14. Outline of Biochemistry. Cohn & Stumpf
15. Introduction to the chemistry of enzyme action. Williams:
16. The Organic Chemistry of Drug design and Drug action. R. B. Silverman Academic press.
17. Strategies for Organic Drug synthesis and Design. D. Lednicer, J. Willey.
18. Heterocyclic Chemistry. Vol-1-3, R. R. Gupta, M. Kumar and V. Gupta, Springer Verlag.
19. The Chemistry of Heterocycles. T. Eicher and S. Hauptmann, Thieme
20. Heterocyclic Chemistry. J. A. Joule, K. Mills and G. F. Smith, Chapman and Hall
21. Heterocyclic Chemistry. T. L. Gilchrist, Longman Scientific Technical
22. Contemporary Heterocyclic Chemistry. G. R. Nikome and W. W. Poudler, Willey
23. An Introduction to Heterocyclic Compounds, R. M. Acheson, J. Willey
24. Comprehensive Heterocyclic Chemistry. A. R. Katritzky and C. W. Rees

Course Outcomes (COs):

CO No.	On completion of the course, students will be able to:
CO1	To know about the drug design, history, and development of quantitative structure-activity relationship (QSAR). Also, learn the concept of drug receptors and the relationship between structure and chemical reactivity. Learn about different types of antibiotics.
CO2	Study the various types of drugs like antimalarials, Anti-inflammatory, anesthetics, Antitubercular, Tranquilizers cardiovascular, and Antineoplastic drugs.
CO3	Understand synthesis and reactions of five, six-membered heterocycles.
CO4	Learn the synthesis and reactions of diazines and triazines. Synthesis of the reactions of azepines, oxepines & thiepinines.

EA-MCTA23-304: Environmental Chemical Analysis and Control

UNIT-I: Sampling in analysis

15 hrs.

Definition, theory and techniques of sampling, sampling of gas, liquids and solids, Criteria of Good sampling, Minimization of Variables, transmission and storage of samples, high pressure ashing techniques (HPAT), particulate matter, its separation in gas stream, Filtering and gravity separation. Analysis of particulate matter like asbestos, mica, dust and aerosols etc

UNIT-II: Electrochemical and spectral methods Environmental analysis

15 hrs.

Introduction to instrumental techniques, principle instrumentation and applications with respect to environmental analysis of Conductometry, Potentiometry, Ion selective electrodes, Cyclic voltammetry, Amperometry, Coulometry, Atomic absorption spectrometry, Atomic fluorescence spectrometry, Inductively coupled plasma spectrometry, Turbidimetry, Non Dispersive Infrared Analysis (NDIR).

UNIT-III: Air and Water Pollutant Analysis

15 hrs.

Chemistry of Air pollutants, characterization. source, methods of analysis of air pollutants; CO, CO₂, NO_x, NH₃, H₂S, SO₂ etc. Monitoring Instruments, Potable and Industrial water, major and minor components, dissolved oxygen (DO) Chemical oxygen demand(COD) Biochemical oxygen demand (BOD) and their measurements. Analysis of Pd, Cd, Hg, Cr, As and their physiological manifestations. Quality of industrial waste water analysis for organic and inorganic constituents. Chemistry of odour and its measurements.

UNIT-IV: Organic Pollutants and Their Analysis**15 hrs.**

Sources, disposal, treatment and analysis of phenolic residues, methods of recovery of phenols from liquid effluents, Organomercurials and its analysis, Analysis of organochlorine pesticides, volatile organic pollutants and their analysis

Reference books:

1. A.K. De: Standard Methods of Waste and Waste water analysis.
2. P. M. S. Monk Fundamentals of Electroanalytical chemistry-John Wiley & Sons (2001)
3. Instrumental methods of chemical analysis H. Kaur
3. S.M. Khopkar, Environmental Chemistry; Environmental pollution analysis
4. M.S. Creos and Morr, Environmental Chemical Analysis, American publication (1988)
5. A.K. De, Environmental Chemistry, New Age International publishers. Moghe and Ramteke, Water and waste water analysis: (NEERI)
6. A.C. Stern, Air pollution: Engineering control Vol. IV(AP)
7. P.N. Cheremisinoff and R.A. Young, Air Pollution control and Design. Hand Book Vol. I & II (Dekker)
8. R.B. Pohasek, Toxic and Hazardous waste disposal, Vol. I & II (AAS)
9. M. Sitting, Resources Recovery and Recycling, Handbook of industrial Waste.
10. B.K. Sharma, Industrial Chemistry.
11. S.P. Mahajan, Pollution Control in Process Industries.
12. R.A. Horne, Chemistry of our Environment.

Course Outcomes (COs):

- CO1: Students will acquire knowledge about sampling, criteria of good sampling, handling, preservation and storage of the samples, pretreatment and post treatment of samples.
- CO2: Students will acquire knowledge of conditions and strategies required during sampling and electrochemical and spectral methods for analysis of environmental samples.
- CO3: Students will learn about the air and water pollution, sources of pollution, typical parameters and properties (physical, chemical and biological) to be measured in air and water pollution with relevance to specific case studies.
- CO4: Students will be acquainted with organic pollutants and their analysis with special reference to pesticide analysis.

RP- MCPO23-305: Research Project (4 Cr)

See Annexure-I for details. (Page No. 28)

MJ-MCPO23-306: Organic Chemistry Practical (2 Cr.) 60 hrs.

A) Qualitative Analysis

Separation, purification and identification of compounds (any two) of ternary mixtures using semi- microanalysis, TLC, column chromatography, and chemical tests. IR spectra to be used for functional group identification.

B) Quantitative analysis

1. Two step Preparations (Any Five)

- a) Preparation of m-Nitroaniline
- b) Preparation of Benzanilide from benzophenone
- c) Preparation of Phthalimide
- d) Preparation of N-Bromosuccinimide
- e) Preparation of 4-methyl -7-acetoxy coumarin
- f) Preparation of 1, 2, 3, 4- Tetrahydro carbazole
- g) Preparation of p-ethoxy acetanilide

Reference books:

1. Textbook of Practical Organic Chemistry – A. I. Vogel.
2. Practical Organic Chemistry – Mann & Saunders.
3. A Handbook of Quantitative & Qualitative Analysis- H. T. Clarke.
4. Organic Synthesis Collective Volumes by Blat

NOTE: Student should perform their practical work in the laboratory minimum 15 days in one semester for 2 credits.

MJ-MCTO23-401: Theoretical Organic Chemistry

UNIT-I: Molecular Orbital Theory **15 hrs.**

Aromaticity in benzenoids, alternant and non- alternant hydrocarbon, Huckels rule, energy level of π - molecular orbital and concept of aromaticity, calculation of energies of orbitals cyclic and acyclic systems. Determination energies and stabilities of different systems calculation of charge densities PMO theory and reactivity index.

UNIT-II: Non benzenoid aromatic Compounds **15 hrs.**

Aromaticity in non-benzenoid compounds Annulenes and heteroannulenes, fullerenes, azulene, fulvene, tropylium salts, ferrocene, five-membered systems. Crown ether complexes, cyclodextrins, cryptands, catenanes, and rotaxanes, bonding in fullerenes.

UNIT-III: Green Chemistry **15 hrs.**

Introduction to the principles of green chemistry – prevention of waste, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, reducing derivatives, renewable feedstock, catalysis, design for degradation, real-time analysis for pollution prevention, and inherently safer chemistry for accident prevention. Green synthesis, clean routes using supercritical solvents, ionic liquids, and water.

UNIT-IV: **15 hrs.**

(A) Kinetic and thermodynamic control of reactions **(9)**

Nitration and Sulphonation of naphthalene, Wittig, Enolization, Friedel-Crafts and Diels Alder reactions.

(B) Non-classical carbocations: Formation, stability, and reactivity. **(6)**

Reference Books:

- a. Lehar and Merchand: Orbital Symmetry.
- b. R. B. Woodward and Hoffman: Conservation of orbital symmetry.
- c. P. T. Anastas, J. C. Werner: Green Chemistry: Theory and Practice
- d. V. K. Ahluwalia: Green chemistry, A textbook
- e. V. K. Ahluwalia, R. S. Verma: Green Solvents: For Organic Synthesis
- f. Ginsburg: Nonbenzenoid aromatic compound.
- g. A. Streitwieser: Molecular orbital theory for organic chemistry.
- h. E. Cler: The aromatic sextet.
- i. Lloyd: Carbocyclic non- benzenoid aromatic compounds.
- j. W. B. Smith: Molecular orbital methods in organic chemistry.
- k. Grratt; Aromaticity

Course Outcomes (COs):

CO No. On completion of the course, students will be able to:

- CO1 Understand the concept of aromaticity, Huckel's rule, the energy level of pi-molecular orbital, calculation of energies of cyclic and acyclic systems, calculation of charge densities, PMO theory, and reactivity index.
- CO2 Learn synthesis and reactions of Linear and Non-linear polynuclear hydrocarbons. Understand the concept of aromaticity and anti-aromaticity as well as the concept of 3- and 5- 5-membered carbocyclic compounds, crown ethers, cyclodextrins, catenanes, and rotaxanes.
- CO3 Understand the types of free radicals, detection by ESR, reaction mechanism, and reactivity. They also learn the effect of solvent on reactivity, Sandmeyer's reaction, Hunsdiecker reaction.
- CO4 Learn about the Kinetic and thermodynamic control of nitration and sulphonation, about Wittig reaction, Enolization, F. C. reaction, and Diel's Alder reaction. Understand Non-classical carbonation - Formation, stability, reactivity, and synthetic applications.

MJ-MCTO23-402: Stereochemistry

UNIT-I: Conformational analysis and reactivity of acyclic and alicyclic compounds 15 hrs.

A) Conformational analysis of acyclic compounds (4)

The difference between configuration and conformation, torsion strain, Pitzer strain, the effect of (i) van der Waals interactions, (ii) hydrogen bonding, and (iii) dipole moment on the stability of conformation with examples, gauche effect.

B) Conformational analysis of cyclohexane compounds (4)

Concept of Baeyer ring strain, ring inversion, locking of conformations and group. Conformations of (1, 4-di-t-butyl)cyclohexane, 1, 4-cyclohexanediol, menthol, cyclohexanone.

C) Effect of conformation on reactivity (mechanism) of acyclic and cyclic systems (7)

Curtin-Hammett principle. Effect of conformation on the course and rate of reactions in cyclohexane; debromination of 2,3-dibromobutane, semipinacolic deamination of 1,2-diphenyl-1-(pchlorophenyl)-2-amino ethanol, dehydrohalogenation of stilbene dihalide and bromo-1,2-diphenyl propane, stereochemistry of molecular rearrangements; pyrolytic cis-elimination.

UNIT- II: Conformational analysis and reactivity of the fused and bridged ring system 15 hrs.

A) Fused rings: Types of fused ring systems; (i) Fused bicycles: cis and trans-decalins, octalins, decalols, (ii) Fused poly-bicycles: perhydroanthracene and perhydrophenanthrene (iii) effect of angular methyl group on conformation of fused ring system.

B) Bridged rings: Types of bridged ring systems, nomenclature, bridged bicycles: heptanes and octane, stereochemical restrictions, Bredt's rule.

UNIT- III: Stereoselective Synthesis 15 hrs.

A) Stereoselective addition of nucleophiles to carbonyl group (6)

Cram's rule, Felkin Ahn rule, Houk's model, Cram's chelate model. Asymmetric synthesis by use of chiral auxiliaries, use of chiral substrates, reagents, and catalysts

B) Asymmetric Synthesis (9)

Asymmetric epoxidation of allylic alcohols (Sharpless Epoxidation), Dihydroxylation of olefins: Sharpless asymmetric dihydroxylation, Upjohn process, Milas hydroxylation. Asymmetric Diels-Alder Reactions using chiral Lewis acids: Chiral bisulfonamides (Corey's catalyst).

UNIT- IV: Stereochemistry of compounds containing no chiral carbon atoms **15 hrs.**

A) Stereochemistry of allens, spirans and biphenyls, assignment of configuration **(4)**

B) Configuration of diastereomers **(4)**

Geometrical isomerism based on physical and chemical methods.

C) O.R.D. and C.D. **(7)**

ORD and CD curves with Cotton effect. Empirical and semi-empirical rules; The octant rule, helicity rule, Lowe's rule, and axial haloketone rule.

Reference Books:

1. E.L. Eliel: Stereochemistry of carbon compounds.
2. D. Nasipuri : Stereochemistry of organic compounds.
3. P.S. Kalsi: Stereochemistry, Conformation and Mechanism.
4. Eliel, Allinger, Angyal and Morrison: Conformational analysis.
5. Hallas: Organic stereochemistry.
6. Mislow and Benjamin: Introduction to Stereochemistry.
7. H. Kagan: Organic stereochemistry.
8. Carl Djerassi; Optical Rotatory Dispersion.
9. P. Crabbe: Optical Rotatory Dispersion and C.D.

Course Outcomes (COs):

CO No. On completion of the course, students will be able to:

- CO1 Approve the knowledge of about stereoselective, stereospecific synthesis, chemoselective and regioselective reactions. Understand the enantioselective synthesis, reactions with hydride donor, catalytic hydrogenation via chiral hydrazones and oxazolines etc.
- CO2 Understand in depth stability and reactivity of diastereoisomers, Curtin-Hammett principle, some aspects of stereochemistry of ring compounds. The shapes of the 5, 6 and 7 membered rings. Also, they will learn the conformational effects in medium sized rings and the concept of I-strain.
- CO3 Knowledge about conformation and configuration of fused bicyclic rings and bridged rings, stereochemical restrictions, and Bredt's rule.
Understand O. R. D. and C. D. curves, circular dichroism, the Octane rule and axial haloketone rule.
- CO4 Explain the stereochemistry of Allenes, Spiranes, and Biphenyls and how to assign the configuration and by using physical and chemical methods.

MJ-MCTO23-403: Chemistry of Natural Products

UNIT-I: Terpenoids

15 hrs.

Introduction of natural products and Terpenoids: Introduction of natural products: Classification and isolation methods. Terpenoids: Structure and synthesis of camphor, carvone, abietic acid, zingiberene, α -santonin, β -cuparenone. Biogenesis of abietic acid.

UNIT-II: Alkaloids

15 hrs.

Structure, stereochemistry, synthesis, and biosynthesis of the following: Morphine, Reserpine, Papaverine, and Lysergic acid. Biogenesis of Coniine.

UNIT-III: Steroids

15 hrs.

Occurrence, nomenclature, basic skeleton, Diels hydrocarbon. **Study of the following:** ormones (Structure and synthesis): Cholesterol, Androsterone, Testosterone, Estrone, Progesterone, Aldosterone and cortisone Bile acid (only synthesis) and biosynthesis of lanosterol.

UNIT-IV: Study of Prostaglandins, Lipids and Vitamins

15 hrs.

A) Prostaglandins:

(5)

Occurrence, nomenclature, classification, biogenesis and physiological effects, Synthesis of PGE₂ and PGF₂.

B) Lipids:

(4)

Classification, Role of Lipids, Fatty acids and glycerol derived from oils and fats.

C) Vitamins:

(6)

Synthesis and structure of biotin, vitamin B₁ and B₂, Biological functions of Vitamin B₆, D and E.

Reference Books:

1. Apsimon: The total synthesis of natural products.
2. Manskey and Holmes: Alkaloids
3. A.A. Newmen: Chemistry of Terpenes.
4. P. D B. Mayo: The chemistry of natural products.
5. Simonson: Terpenes.
6. T.W. Goddwin: Aspects of terpenoid chemistry and biochemistry.
7. R.T. Slicken staff A.C. Ghosh and G.C. Wole: Total synthesis of steroids.
8. The chemistry of natural products, vol. Nakanishi
9. Biochemistry of Lipids, Lipoproteins and membranes by Neele Ridgway and Roger McLeod
10. Membranes (New comprehensive biochemistry) by J E Vance and E Vance

Course Outcomes (COs):

CO No. On completion of the course, students will be able to:

- CO1 Learn the classification, isolation of terpenoids, structure, and synthesis of Camphor, Carvone, Abietic acid, zingiberene, alpha-santonin, and beta-caryophyllene.
- CO2 Know all about Alkaloids the occurrence, isolation, structures, functions, stereochemistry, and synthesis of Morphine, Reserpine, Atropine, and Conin alkaloids.
- CO3 Learn the occurrence, nomenclature, and basic skeleton of steroids as well as the synthesis of hormones like cholesterol, Androsterone, Testosterone, and Estrone. Also study the nomenclature, classification, biogenesis, physiological effects, and synthesis of prostaglandin PGE2 and PGF2.
- CO4 Study about the Vitamins as well as synthesis and biological functions of vitamins B1, B2, B5, B6, and Biotin i.e. vitamin H.

Major Electives (Choose any One)

M.Sc. II, SEM-IV

Students of Organic and Analytical Chemistry shall choose any one of the following elective papers.

EO-MCTO23-404: Applied Organic Chemistry

UNIT-I: Study of Agrochemicals and Perfumes

15 hrs.

A) Agrochemicals

(7)

(i) Organochlorine pesticides: Introduction, synthesis, and mode of action of endrin, aldrin, dieldrin. (ii) Herbicides: Synthesis and mode of action of Triazines, triazoles, pyridazinones, and bipyridylum compounds: diquat, paraquat. (iii) Juvenile hormone: introduction & structures JHA importance synthesis, IPM

B) Synthesis and applications of perfumery

(8)

2-Phenylethanol, vanillin, and other food flavors, synthetic musk, and ionones.

UNIT-II: Unit processes

15 hrs.

Introduction to unit operation and unit processes. Nitration: Introduction, Nitrating agents, kinetics and mechanism, oxynitration, typical industrial nitration process.

Amination: Introduction, Bechamp reduction. Halogenation: Introduction, Kinetics and mechanism, catalytic chlorination, manufacturing process for chlorobenzene and

monochloroacetic acid. Sulfonation- Introduction, sulphonating agents, kinetics and mechanism, manufacturing process for benzene sulphonic acid.

UNIT-III: Dyes and Intermediates

15 hrs.

Classification and synthesis of important dye intermediates by using nitration, sulphonation, diazotization reactions. Synthesis of Nitro dyes, xanthenes, reactive dyes, fluorescent brightening agents, thermal sensitive dyes, dispersed dyes and reactive dyes.

UNIT-IV: Polymers

15 hrs.

Mechanism of polymerization. Industrial process for synthesis of polyethylene, acrylonitrile, acrylate and methacrylate polymer, biomedical polymer, polymer processing, Plasticizers and anti-oxidants for polymers,

Reference Books:

1. Allan: Colour Chemistry
2. K. Venkataraman: Chemistry of Synthetic Dyes Vol- 1 to 7
3. G. R. Chatwal: Synthetic dyes
4. Abrahart: Dyes & their intermediates
5. N. N. Melikov: The Chemistry of Pesticides and formulations
6. K. H. Buchel: Chemistry of Pesticides.
7. R. Clemlyn: Pesticides
8. K. H. Buchel: Chemistry of Pesticides
9. H. R. Alcock and F. W. Lambe: Contemporary Polymer Chemistry
10. J. M. G. Cowie, Blackie: Physics & Chemistry of Polymers
11. I. M. Campbell: Introduction to Synthetic Polymers
12. A. L. Gupta: Polymer Chemistry
13. M. S. Bhatnagar: A textbook of Polymers
14. F. W. Billmeyer: Textbook of Polymer Science

Course Outcomes (COs):

CO No. On completion of the course, students will be able to:

CO1 Learn about the synthesis and uses of different types of Agrochemicals such as Carbamates, organophosphorous insecticides, and Natural and Synthetic Pyrethroids. They will learn the synthesis of some plant growth regulators as well as applications of Juvenile hormones and Pheromones.

- CO2 Learn about the perfumery compounds, commercial process, preparation and importance of essential oils. Also learn the synthesis of 2 - phenyl ethanol, yara- yara, vanillin, synthetic musk, jasmine, ionone etc. from citral, phenyl acetate ester, benzyl acetate ester.
- CO3 Understand the classification, and synthesis of azo dyes, reactive dyes, optical brighteners, dispersed dyes.
- CO4 Understand the mechanism of polymerization. Also, study about the manufacturing processes of synthetic rubber plasticizers, and anti-oxidents required for natural polymers like starch and cellulose. They will get the knowledge about the Oxo and Wacker process necessary for Soap and Synthetic detergents.

EA-MCTA23-404: Applied Analytical Chemistry

UNIT-I: Spectrochemical Methods of Analysis 15 hrs.

Introduction to spectrochemical methods. Electronic spectra and molecular structure, NIR spectrometry for non-destructive testing. Solvents for spectrometry, FTIR spectrometer, fluorometry, optical sensors. Analysis of ores –bauxites, dolomites, monazites. Analysis of Portland cement.

UNIT-II: Analysis of metals and alloys 15 hrs.

Foundry materials, ferroalloys, and special steels, slags, fluxes. Analysis of alloys, bronze, brass, Alnico and Nichrom.

UNIT-III: Analysis of soil and fertilizers 15 hrs.

Method of soil analysis, soil fertility and its determination, determination of inorganic constituents of plant materials, Chemical analysis as measure of soil fertility, analysis of fertilizers, applications.

UNIT-IV: Analysis of Commercial materials 15 hrs.

Analysis of explosive materials, TNT, RDX, lead azide, EDNA (ethylene dinitramine). Analysis of conducting polymer, resins and rubber. Analysis of luminescent paints, Analysis of lubricants and adhesive.

Reference Books:

1. Hillebrand Lhundel, Bright and Hoffiman, Applied Inorganic Analysis, John Wiley.
2. Snell and Biffen, Commercial Methods of Analysis.
3. P. G. Jeffery, Chemical Methods of Rock Analysis, Pergamon.
4. Buchel, Chemistry of Pesticides. J Wiley.
5. Rieche, Outlines of Industrial Organic Chemistry, Butter Worth.
6. F. A. Henglein, Chemical Technology, Pergamon.
7. Kent, Riegl's Industrial Chemistry, Rainhold.
8. Chopra and Kanwar, Analytical Agriculture Chemistry, Kalyani Publishers.
9. Aubert and Pintes, Trace Elements in Soils.
10. Bear, Chemistry of Soil.
11. Hauson, Plant Growth Regulators, Noyes.
12. P. G. Jeffery and D.J. Hatchinson, Chemical Methods of Rock Analysis.
13. F. J. Weleher, Standard Methods of Chemical Analysis, A Series of Volumes Robert and Krigegeger Publishing Company.
14. I. M. Kolthoff and PJ Ewing, Treatise o Analytical Chemistry, A series of Volumes.
15. R. D. Reeves and R.R. Brooks, Trace element Analysis of Geological Materials, John Wiley & Sons New Dehli.
16. W. M. Johnson and J.A. Maxwell, Rock and Mineral Analysis, John Wiley and Sons, New York.
17. W. F. Hildebrand, GHC Landell and HA Brighot, Applied Inorganic Analysis, John Wiley 2nd Ed.
18. K. J. Das, Pesticide Analysis (MD).

Course Outcomes (COs):

- CO1: The students will acquire knowledge of analysis of metals, alloys, minerals and ores commonly used in the industry.
- CO2: The students will be acquainted with the analysis of real samples like cement, plaster of Paris, different commercial ores, soil composition, soil fertility, fertilizers etc using conventional and instrumental methods of analysis.
- CO3: Students will also gain the knowledge of analysis of commercial materials, explosives, polymers, resins, rubber, luminescent paints, lubricants and adhesives.
- CO4: These would offer opportunity to the students to get employment in industries for quality assurance and quality control (QA-QC) of the product.

RP-MCPO23-405 Research Project (6 Cr)

See Annexure-I for details.

Note: Study tour is the part of your syllabus for M.Sc. Part- II. Students shall visit Chemical Industries in India.

Annexure-I

Research Project Paper Guidelines for all specializations

(Organic and Analytical Chemistry)

Semester III

(RP-MCPO23-305, RP-MCPA23-305)

Credits= 04, 120 Hours, 100 Marks

- The students should write synopsis of proposed research work.
- The students should perform detail literature survey related to research problem.
- The students should write review article related to research problem.
- It is expected to publish the review article either in Shivaji University Journal or peer reviewed journals.
- The students should design the problem and start experimental work. The students should complete at least 25% of their experimental work during the semester III and the same work to be continued in semester IV.
- The student should submit the spiral bound copy of research work carried out during semester III including the synopsis, research proposal, review article and certified progress report.
- The Research Project will be examined jointly by internal and external examiners during the practical examination at the end of the semester.
- The students should present their work during the evaluation in the form of power point presentation (PPT) .
- Marking Scheme:

Sr. No.	Description	Marks
1	Synopsis	10
2	Research Proposal	20
3	Review article on proposed work	20
4	Daily Lab notebook record	10
5	Progress of Experimental work	20
6	Quality and effectiveness of presentation	20
	Total	100

Broad guidelines for preparation of synopsis

- A. The proposed synopsis for research should be self-contained and should cover the rationale for carrying out research.
- B. There should not be repetition of the work or topic or theme.
- C. The synopsis of the proposed research shall contain the following points :
 1. Title of the Research Proposal
 2. Motivation with reasoning and significance of the proposed research
 3. Statement of the problem
 4. Review of the relevant literature
 5. Objectives of the study
 6. The methodology comprising
 - a. Methods of research
 - b. Sampling design and assumptions
 - c. Conceptual framework if any
 - d. Research design (explanation of how research is being conducted and the tools used for the same)
 - e. Methods of data collection
 - f. Methods of data analysis (use of parametric and non-parametric tools and techniques as the case may be)
 7. Expected outcome
 8. Bibliography.

Template for Research Proposal

- Title
- Introduction
- Origin of the research problem
- Interdisciplinary relevance
- Review of Research and Development in the Subject
- Significance of the study
- Objectives
- Plan of research work

M. Sc. II Semester IV

(RP-MCPO23-405, RP-MCPA23-405)

Credits= 06, 180 Hours, 150 Marks

- The student should submit the final bound dissertation/thesis copy of research work carried out during semester III and IV.
- It should include title page, certificate, declaration, acknowledgement, abbreviations, index, abstract, introduction, experimental section, results and discussion, conclusions, references, participation in conferences/seminars and publications if any.
- The students should present their work during the evaluation in the form of power point presentation (PPT).
- **Marking Scheme:**

Sr. No.	Description	Marks
1	Dissertation/thesis bound copy	30
2	Quality of work (Innovative concepts, social relevance, extent of work etc.)	50
3	Publications	20
4	Participation in conferences	10 maximum
	a) Oral/Poster Presentation (10 marks)	
	b) Only attended (7 marks)	
5	Final Dissertation/thesis defense	40
	Total	150

Note: The Project will be examined jointly by internal (Project Supervisor) and external examiners (preferably Associate professor and above with Ph. D.) at the end of the semester. The project can be given individually or a maximum group of three students is allowed. (Not more than three students allowed).