Indrashil University

Department of Chemistry
School of Science

M.Sc. 2025-2027 Sem I-IV

Organic Chemistry

Course Profile

Academic Year 2025-2026

Course Structure M.Sc. Organic Chemistry Semesters I to IV

SEMESTER: I	MINIMUM SEMESTER CREDIT REQUIRED: 20 CUMULATIVE SEMESTER CREDITS REQUIRED: 20		
SUBJECT NO.	**SUBJECT NAME**	**L-T-P**	**CREDITS**
CH4 101	ORGANIC CHEMISTRY – I: LOGICS IN ORGANIC REACTION AND MECHANISM	3-0-0	3
CH4 102	INORGANIC CHEMISTRY – I: COORDINATION CHEMISTRY & MAGNETIC MATERIALS	3-0-0	3
CH4 103	PHYSICAL CHEMISTRY – I: MOLECULAR THERMODYNAMICS AND SOLID-STATE	3-0-0	3
CH4 104	ANALYTICAL CHEMISTRY – I: INSTRUMENTAL METHODS OF ANALYSIS	3-0-0	3
CH4 105	QUANTUM MECHANICS FOR CHEMISTS	3-0-0	3
CH4 106	BASIC ORGANIC CHEMISTRY LABORATORY	0-0-8	4
CH4 107	INORGANIC CHEMISTRY LABORATORY	0-0-8	4
Total		**15L-16P**	**23**

SEMESTER: II	MINIMUM SEMESTER CREDIT REQUIRED: 43 CUMULATIVE SEMESTER CREDITS REQUIRED: 23		
SUBJECT CODES	**SUBJECT NAME**	**L-T-P**	**CREDITS**
CH4 201	ORGANIC CHEMISTRY – II: REACTIONS, REAGENTS, AND REARRANGEMENTS	3-0-0	3
CH4 202	INORGANIC CHEMISTRY – II: MAIN GROUP AND ORGANOMETALLIC COMPOUNDS	3-0-0	3
CH4 203	PHYSICAL CHEMISTRY – II: SURFACE AND INTERFACIAL CHEMISTRY	3-0-0	3
CH4 204	BIOORGANIC CHEMISTRY:	3-0-0	3
CH4 205	SPECTROSCOPY – I: MOLECULAR STRUCTURE DETERMINATION	3-0-0	3
CH4 206	ANALYTICAL TECHNIQUES LABORATORY	0-0-8	4
CH4 207	PHYSICAL CHEMISTRY LABORATORY	0-0-8	4
Total		**15L-16P**	**23**

SEMESTER: III	MINIMUM SEMESTER CREDIT REQUIRED: 24 CUMULATIVE SEMESTER CREDITS REQUIRED: 67		
SUBJECT CODES	**SUBJECT NAMES**	**L-T-P**	**CREDITS**
CH5 OR101	ORGANIC CHEMISTRY – III: ORGANOMETALLIC CHEMISTRY AND ASYMMETRIC SYNTHESIS	3-0-0	3
CH5 OR102	ORGANIC CHEMISTRY – IV: CHEMISTRY OF NATURAL PRODUCTS	3-0-0	3
CH5 OR103	ORGANIC CHEMISTRY – V: PERICYCLIC REACTIONS AND ORGANIC PHOTOCHEMISTRY	3-0-0	3
CH5 104	SPECTROSCOPY-II: ADVANCED NMR AND MOLECULAR SPECTROSCOPY	3-0-0	3
CH5 105	SPECTROSCOPY ANALYSIS & DATA INTERPRETATION LABORATORY	0-0-8	4
CH5 OR106	ADVANCED ORGANIC CHEMISTRY LAB	0-0-8	4
	ELECTIVE-I	2-0-0	2
	ELECTIVE-II	2-0-0	2
Total		**16L-16P**	**24**

SEMESTER: IV	MINIMUM SEMESTER CREDIT REQUIRED: 15 CUMULATIVE SEMESTER CREDITS REQUIRED: 82		
SUBJECT CODES	**SUBJECT NAMES**	**L-T-P**	**CREDITS**
CH5 OR201	RESEARCH OR INDUSTRIAL PROJECT	0-0-20	10
CH5 OR202	PROJECT REPORT	3-0-0	3
CH5 OR203	PROJECT PRESENTATION	2-0-0	2
Total		**5L-20P**	**15**

Semester III: LIST OF AVAILABLE SUBJECTS FOR ELECTIVE I, II

SUBJECT CODES	SUBJECT NAMES	L-T-P	CREDIT
CH5 EOR1	MEDICINAL CHEMISTRY	2-0-0	2
CH5 EOR2	APPLICATIONS OF COMPUTERS IN CHEMISTRY	2-0-0	2
CH5 EOR3	SUPRAMOLECULAR CHEMISTRY	2-0-0	2
CH5 EOR4	INDUSTRIAL CHEMICAL METHODS AND ANALYSIS	2-0-0	2

SEMESTER I
SYLLABUS WITH COURSE LEARNING OUTCOME (CLO)

CH4 101: ORGANIC CHEMISTRY-I: LOGICS IN ORGANIC REACTION AND MECHANISM (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 101	**Course name:** ORGANIC CHEMISTRY-I: LOGICS IN ORGANIC REACTION AND MECHANISM

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:
- Understand and apply the fundamental principles of structure and reactivity
- Analyze and compare reaction mechanisms
- Develop proficiency in stereochemical concepts and conformational analysis

Course Learning Outcome: At the end of this course, the students will be able to
CLO1: Familiarize with types of reactions, their mechanisms, and reactivity of organic reactive intermediates
CLO2: Understand the Hammett equation, Hammond's postulate, Curtin-Hammett principle, and HSAB Principle.
CLO3: Get an idea about SNAr, SRN1, and benzyne mechanism, the NGP, and anchimeric assistance.
CLO4: Be able to understand Classical and non-classical carbocations. Aromatic electrophilic substitution reactions, arenium ion mechanism, the ortho/para ratio, ipso attack,
CLO5: Knowledge of Basic principles of Stereochemistry, chirality, Prochiral relationship, and optical activity in biphenyls, spiranes, allenes, and helical structures. Stereochemistry of compounds containing Nitrogen, Sulphur, and Phosphorus.

Syllabus

Units	Contents	Hours
Unit I: Structure and Reactivity	Basic principles of Structure and Reactivity: Chemical bonding; Hybridization; Molecular Geometry, Bond Polarity and Dipole Moment, Resonance and Delocalization, Inductive, Mesomeric Effects and Tautomerism, Hyperconjugation and its Role in Stability; Steric Effects; Electron Donating and Withdrawing Groups; Concept of Aromaticity; Hard and Soft Acids and Bases (HSAB Principle); Frontier Molecular Orbital Theory (HOMO-LUMO Concepts); Thermodynamic vs. Kinetic Control; Hammond's Postulates; Stability and Reactivity of Reactive Intermediates: Carbocations, Carbanions, Free Radicals, Carbenes and Nitrenes; Transition State Theory and Curtin–Hammett Principle; Energy profiles and reaction coordinate, diagrams for Exothermic and Endothermic Reactions; Energy profiles and reaction Coordinate Diagrams for Catalysed and Uncatalysed Reactions; Effect of Solvent Polarity and Proticity; Substituent Effects on Reactivity; Molecular Strain and reactivity; Ring Strain and Bredt's Rule; Baeyer Strain Theory	**15**
Unit II: Organic Reaction Mechanism	**Organic Reaction Mechanism:** Arrow pushing formalism (curved arrow notation); Types of electron movement: homolytic vs. heterolytic cleavage **Types of Reactions and their mechanism:** **Nucleophilic Substitution Reactions:** SN1 and SN2 mechanisms (Stereoelectronic Control in SN1/SN2): kinetics, stereochemistry, and energy diagrams; Neighboring group participation (NGP); Ambident nucleophiles **Elimination Reactions:** E1, E2, and E1cb mechanisms; Hofmann vs. Zaitsev elimination; Base strength and solvent effects; Stereoelectronic requirements and Antiperiplanar geometry	**15**

	Addition Reactions: Electrophilic, nucleophilic, and radical additions; Markovnikov vs. anti-Markovnikov additions; Stereochemistry in *syn/anti* additions; Addition to carbon–heteroatom multiple bonds (e.g., C=O, C=N) **Aromatic Substitution Mechanisms:** Electrophilic aromatic substitution (EAS); Nucleophilic aromatic substitution (NAS): SNAr, benzyne mechanism; Diazonium coupling and related transformations **Radical Reactions:** Generation and stability of radicals; Chain initiation, propagation, termination	
Unit III: Stereochemistry and Conformational Analysis	Fundamental Concepts in Stereochemistry: Isomerism; Constitutional vs. Stereoisomerism; Types of Stereoisomers: Enantiomers, Diastereomers, Meso Compounds; Optical Activity: Chirality, Specific Rotation, Optical Purity; Absolute and Relative Configuration: CIP Rule for R/S Nomenclature; Stereoselective vs. Stereospecific Reactions Projection Formulas and Interconversion Define Fischer, Sawhorse, Newman, and Wedge-Dash Representations; Interconversion of different projections; Stereochemical correlation and configuration assignment Conformational Analysis of Acyclic and Cyclic Systems Conformations of ethane, butane: eclipsed, staggered, gauche, anti; Cyclohexane conformations: chair, boat, twist-boat; Axial/equatorial positions; conformational preference; Energy barriers and conformational equilibrium; Effect of substituents on conformational stability	**15**

Reading references:

1. E. L. Eliel. *Stereochemistry of Carbon Compounds*. TATA McGraw-Hill Publishing Company Ltd., New Delhi. 1962, 1st Ed.
2. D. Nasipuri. *Stereochemistry of Organic Compounds*. New Age International (P) Ltd., Publishers, New Delhi. 1994, 2nd Ed.
3. P. S. Kalsi. *Stereochemistry: Conformation and Mechanism*. New Age International (P) Ltd., Publishers, New Delhi. 2019, 10th Ed.
4. J. March. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*. Wiley-Interscience, A John Wiley & Sons, Inc., New York. 2006, 6th Ed.
5. P. Sykes. *A Guidebook to Reaction Mechanisms in Organic Chemistry*. Longman Scientific & Technical, Essex. 1986, 6th Ed.
6. S. M. Mukherji; S. P. Singh. *Reaction Mechanism in Organic Chemistry*. Macmillan India Ltd., New Delhi. 1976, Revised Ed.
7. L. G. Wade Jr. *Organic Chemistry*. Pearson Education, New Delhi. 2011, 8th Ed.
8. F. A. Carey; R. J. Sundberg. *Advanced Organic Chemistry, Part A and Part B: Structure and Mechanisms*. Springer, New York. 2007, 5th Ed.
9. J. Clayden; N. Greeves; S. Warren; P. Wothers. *Organic Chemistry*. Oxford University Press, Oxford. 2014, 2nd Ed.

CH4 102: INORGANIC CHEMISTRY-I: COORDINATION CHEMISTRY & MAGNETIC MATERIALS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 102	**Course name:** INORGANIC CHEMISTRY-I: COORDINATION CHEMISTRY & MAGNETIC MATERIALS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- Learn about different types of isomers, coordination polyhedra and molecular symmetry.
- Understand redox reactions, the Nernst equation
- Comprehend inorganic reaction mechanisms
- Have a concept of magnetic materials, calculation of magnetic moment

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Identify different coordination isomers.
CLO2: Compare different strengths of acids and bases.
CLO3: Classify the molecular symmetry by using the group theory concept.
CLO4: Develop the concept of a redox reaction, the Nernst equation, and Inorganic reaction mechanisms.

Syllabus

Units	Content	Hours
Unit I: Isomerism	**Principles of Inorganic Chemistry**: Isomerism, Structural and stereoisomerism of tetrahedral, square planar and octahedral complexes, facial and meridional isomers, methods to distinguish cis and trans isomers, the concept of ligand- ambidentate, chelating, innocent, non-innocent and bridging ligand, flexidentate behavior of polydentate ligand, Chelate complex, EDTA, Coordination polyhedra - Enumeration of geometrical and optical isomers.	**15**
UNIT-II Molecular Symmetry, Structure, and Reactivity	***Symmetry and Group Theory***: Definitions and theorems of group theory, subgroups, Classes Molecular symmetry and symmetry groups – symmetry elements and operations. Symmetry planes, reflections, inversion centre, proper/ improper axes of rotation, products of symmetry operations, equivalent symmetry elements and atoms, symmetry elements and optical isomerism, symmetry point groups, classes of symmetry operations. **Inorganic Reaction Mechanisms:** Substitution reactions - Dissociative and associative interchange - trans-effect: polarization theory, pi-complexing theory, cis effect, and -redox reactions, concept of oxidant and reductant, disproportionation and comproportionation reaction, std electrode potential and electrochemical series, formulation of Nernst equation, calculation of k value for given inorganic reaction, Latimer diagram, redox indicator, Z-R solutions.	**15**
III Magnetism and Inorganic Compounds	**Magnetic Properties:** Classification of magnetic materials; Cooperative phenomena – Diamagnetism, Paramagnetism, ferro, anti-ferro and ferrimagnetism, Magnetic permeability, molar susceptibility, Magnetic moment, quenching of magnetic moment: 1. By super exchange process, 2) by metal-metal direct bond formation(compounds of Cr and Cu), Curie equation, effect of orbital contribution to spin magnetic moment in oct. and tet-field for d^n ion and calculation of effective magnetic moment.	**15**

Reading references:

1. P. Atkins; T. Overton; J. Rourke; M. Weller; F. Armstrong. *Shriver and Atkins' Inorganic Chemistry*. W. H. Freeman and Company, New York. 2009, 5th Ed.
   or
   D. F. Shriver; P. W. Atkins. *Inorganic Chemistry*. W. H. Freeman and Company, New York. 1999, 3rd Ed.
2. C. Housecroft; A. G. Sharpe. *Inorganic Chemistry*. Prentice Hall/Pearson Education, Harlow. 2008, 3rd Ed.
   or
   C. Housecroft; A. G. Sharpe. *Inorganic Chemistry*. Prentice Hall/Pearson Education, Harlow. 2012, 4th Ed.
3. F. A. Cotton; G. Wilkinson. *Advanced Inorganic Chemistry*. John Wiley & Sons, New York. 1988, 5th Ed.
   or
   F. A. Cotton; C. A. Murillo; M. Bochmann; R. N. Grimes. *Advanced Inorganic Chemistry*. John Wiley & Sons, New York. 1999, 6th Ed.
4. J. E. Huheey; E. A. Keiter; R. L. Keiter. *Inorganic Chemistry: Principles of Structure and Reactivity*. Prentice Hall, New Jersey. 1997, 4th Ed.
5. G. L. Miessler; D. A. Tarr. *Inorganic Chemistry*. Pearson Education, New Delhi. 2004, 3rd Ed.
6. G. Wulfsberg. *Inorganic Chemistry*. University Science Books, Sausalito. 2000, 2nd Ed.

CH4 103: PHYSICAL CHEMISTRY-I: MOLECULAR THERMODYNAMICS AND SOLID-STATE PROPERTIES (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 103	**Course name:** PHYSICAL CHEMISTRY-I: MOLECULAR THERMODYNAMICS AND SOLID-STATE PROPERTIES

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- Understand and apply the principles of statistical thermodynamics to explain macroscopic thermodynamic behaviour.
- Analyze complex chemical reaction mechanisms through kinetic models, including steady-state and transition state theories, and explore experimental techniques.
- Explore the structural and dynamic properties of solids, including crystal symmetry, defects, and polymorphism, with relevance to materials and pharmaceutical sciences.
- Examine the thermal and electronic properties of solid-state materials.

Course Learning Outcomes: In brief, through this course, the students will be able to
CLO1: Connect statistics and thermodynamics. Build the fundamental understanding of the computational world.
CLO2: Understand the rate laws of complex reactions.
CLO3: Analyze the scientific insights of chemical kinetics of complex reactions.
CLO4: Demonstrate the ability to identify different bonding contributions in the solid state.
CLO5: Acquire the knowledge of polymorphism which will help the students in the pharma industry.

Syllabus

Units	Content	Hours
Unit I: Statistical Thermodynamics and Applications in Chemistry	**Statistical Thermodynamics:** Limitations of classical thermodynamics. Introduction to terms like ensemble, population, equipartition of energy, degeneracy. Boltzmann's distribution law, partition function, Distinguishable and indistinguishable particles, molar partition function, Electronic, Translational, Rotational, and Vibrational partition functions. Fermi-Dirac statistics and Bose-Einstein statistics distribution law, and their application. Applications of statistical thermodynamics- Heat capacity behavior of solid and calculation of equilibrium constant, variation in equilibrium constant with temperature and pressure, Le Chatelier's Principle.	**15**
Unit II: Chemical Kinetics and Dynamics	**Chemical Kinetics:** Revision and basics of simple chemical kinetics. Reactions approaching equilibrium, steady state approximation, Complex Reactions: Rate laws for consecutive, opposing, parallel reactions, explosive reactions, chain reactions. Comparison between gas phase and solution reactions, factors determining rates in solution. Reaction between ions, reactions involving dipoles, reactions in solution, and the solvent reorganization energy. *Fast reactions*: Relaxation, stop flow, and flash photolysis. Introduction to ultrafast spectroscopy and femtochemistry. Kinetics of enzyme-catalyzed reactions: Michaelis-Menten mechanism, Lineweaver-Burk plot, Harpoon mechanism and its study using molecular beam techniques, Applications of kinetic isotope effects in reaction mechanism studies. Basics of simple collision theory**.** *Activated complex theory*: Reaction coordinate and the transition state theory, potential energy surface, rate constant derivation. experimental evidence on transition state and activated complex. Theories of uni-molecular reactions:	**15**
Unit III:	**Solid State Chemistry: Crystallography**- Recapitulation, diffraction properties	**15**

Crystalline Materials: From Lattice to Device	of crystals. Symmetry elements, space groups. Concept of crystal planes, Miller indices. Ionic crystals. Determination of crystal structure. Imperfection in crystals-point defects (Thermodynamic treatment) and line defects. Crystal growth, engineering, polymorphism, and drug polymorphism regulatory issues. **Thermal Properties:** Lattice vibrations - phonon spectrum; Lattice heat capacity; Thermal expansion; Thermal conductivity. **Electrical Properties:** Free electron theory (Drude model, limitations)- electrical conductivity and Ohm's law - Hall effect; Band theory - band gap - metals and semiconductors - intrinsic and extrinsic semiconductors; Temperature dependence on conductivity. Hopping semiconductors and disordered semiconductors; Semiconductor/metal transition; p-n junctions; Organic semiconductors and perovskites. Superconductors - Meissner effect - type I and II superconductors - isotope effect – basic concepts of BCS theory - manifestations of the energy gap - Josephson devices. High-temperature superconductors and cuprates.	

Reading references:

1. M. C. Gupta. *Statistical Thermodynamics*. New Age International Publishers, New Delhi. 1998, Revised Printing.
2. T. L. Hill. *An Introduction to Statistical Thermodynamics*. Dover Publications, New York. 1986, 1st Ed.
3. B. N. Roy. *Fundamentals of Classical and Statistical Thermodynamics*. Wiley, New Delhi. 2002, 1st Ed.
4. K. J. Laidler. *Chemical Kinetics*. Pearson Education, Noida. 1987, 3rd Ed.
5. R. D. Levine. *Molecular Reaction Dynamics*. Cambridge University Press, New York. 2009, Paperback Ed.
6. Raja Ram; J. C. Kuriacose. *Kinetics and Mechanism of Chemical Transformations*. Macmillan India Ltd., New Delhi. 1993, 1st Ed.
7. S. Glasstone. *Textbook of Physical Chemistry*. Macmillan Publishers, London. 1942, 2nd Ed.
8. P. Atkins. *Physical Chemistry*. Oxford University Press, Oxford. 2018, 8th Ed.
9. M. M. Woolfson. *An Introduction to X-ray Crystallography*. Cambridge University Press–Vikas Publishing House, New Delhi. 1980, 2nd Ed.
10. W. Cochran. *Dynamics of Atoms in Crystals*. Edward Arnold, London. 1973. (pp. 24–37).
11. P. M. A. Sherwood. *Vibrational Spectroscopy of Solids*. Cambridge University Press, Cambridge. 1972. (pp. 1-45).
12. C. N. R. Rao; K. J. Rao. *Phase Transitions*. Cambridge University Press, Cambridge. 1st Ed.
13. G. H. Stout; L. H. Jenson. *X-ray Structure Determination: A Practical Guide*. Macmillan Publishing Co. Inc. and Collier Macmillan Publishers, New York. 1989, 2nd Ed.
14. Gurdeep Raj. *Advanced Physical Chemistry*. Krishna Prakashan Media Pvt. Ltd., Meerut. 2022, 1st Ed.

CH4 104: ANALYTICAL CHEMISTRY-I: INSTRUMENTAL METHODS OF ANALYSIS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 104	**Course name:** ANALYTICAL CHEMISTRY-I: INSTRUMENTAL METHODS OF ANALYSIS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- This course covers the basics of Analytical Chemistry.
- They will understand the importance of analytical science in real-world applications.
- Learn fundamental knowledge of spectrophotometric techniques
- This course enhances scientific understanding and prepares students for industry roles.
- Students will also learn most of the chromatographic techniques and their principles

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Know the importance of Analytical science in the Research & Development of an industry.
CLO2: Operate several analytical instruments within a very short period.
CLO3: Understand several analytical data representation techniques.
CLO4: Learn the techniques to analyze unknown samples.
CLO5: Be familiar with several computer-based data plots.

Syllabus

Unit	Content	Hours
Unit I: Principles, Errors, and Quality Assurance	Scope of analytical chemistry, Qualitative and quantitative analysis, Accuracy and precision, Types of errors and their causes; Significant figures, Control charts, Confidence limit, Mean deviation, Standard deviation, Coefficient of variance, Rejection of a result- the Q-test. Good Laboratory Practice (GLP), Standard operating procedures, Quality assurance and quality control, Finding the best straight line-least square regression, correlation coefficient; Calibration curves, Concept of reference material internal standards,	**15**
Unit II: Spectrophotometric Methods and Optical Techniques in Chemical Analysis	Properties of light, absorption of light, interaction of light with matter and origin of spectra. The spectrophotometer- calibration, sources of light, monochromators and detectors. Beer's law in chemical analysis, optical rotatory dispersion and circular dichroism, Stoichiometry-method of continuous variation-the Jobs plot, Photometric titrations. Atomic absorption spectroscopy.	**15**
Unit-III: Chromatographic Techniques: Principles, Methods, and Instrumentation	Principles of chromatography, Classification and mechanism of different chromatographic methods, Paper chromatography, Thin layer chromatography, Column chromatography, High-performance thin-layer chromatography, Fast protein liquid chromatography. High performance liquid chromatography, Gas chromatography, Detectors.	**15**

Self-learning topics:
Unit-I Scope of analytical science and its literature, ways to express accuracy and precision
Unit-II sources of light.
Unit-III Basic Chromatographic Principles

Reading references:

1. D. A. Skoog; D. M. West; F. J. Holler; S. R. Crouch. *Fundamentals of Analytical Chemistry*. Brooks/Cole Publishing, Belmont. 2013, 9th Ed.
2. E. Prichard; V. Barwick. *Analytical Chemistry by Open Learning (Set of 34 Titles)*. Wiley India, New Delhi. 2008, 1st Ed.
3. D. A. Ray; Underwood. *Quantitative Analysis*. Prentice-Hall International Ltd., New Delhi. 1991, 6th Ed.
4. G. H. Jeffery; J. Bassett; J. Mendham; R. C. Denny. *Vogel's Textbook of Quantitative Inorganic Analysis*. Longman Scientific & Technical, Essex. 1989, 5th Ed.
5. G. D. Christian. *Analytical Chemistry*. John Wiley & Sons Inc., New York. 1994, 6th Ed.
6. G. R. Chatwal; S. K. Anand. *Instrumental Methods of Chemical Analysis*. Himalaya Publishing House, Mumbai. 2016, 5th Revised and Enlarged Ed.
7. H. H. Willard; L. L. Merritt; J. A. Dean. *Instrumental Methods of Analysis*. Van Nostrand Reinhold, New York. 1974, 5th Ed.
   and
   H. H. Willard; L. L. Merritt; J. A. Dean. *Instrumental Methods of Analysis*. CBS Publishers, New Delhi. 1986, 6th Ed.
8. H. Kaur. *Analytical Chemistry*. Pragati Prakashan, Meerut. 2021, Paperback Ed.
9. D. C. Harris. *Quantitative Chemical Analysis*. W. H. Freeman and Company, New York. 1998, 5th Ed.
10. G. D. Christian. *Analytical Chemistry*. John Wiley & Sons Inc., New Jersey. 2004, 6th Ed.
11. D. A. Skoog. *Principles of Instrumental Analysis*. Holt Saunders International Edition, New York. 2016, 7th Ed.
12. G. W. Ewing. *Instrumental Methods of Chemical Analysis*. International Student Edition, New York. 1975, 4th Ed.

CH4 105: QUANTUM MECHANICS FOR CHEMISTS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester: I**
Course code: CH4 105	**Course name:** QUANTUM MECHANICS FOR CHEMISTS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objective: The students will learn

- The different types of mathematical tools can be understood and their applications.
- Postulates of quantum mechanics, Schrödinger equation and its application, Heisenberg Uncertainty principle to understand the basics for quantum chemistry.
- Qualitative treatment of simple harmonic oscillator model of vibrational motion: Vibrational energy of diatomic molecules and zero-point energy to understand the various types of motions and energy in atoms or molecules.
- Chemical bonding to understand the concept about the different kind of chemical bonding and molecular orbital.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Remember the concept of different mathematical tools and their applications.
CLO2: Understand the concept of postulates of quantum, Schrodinger equation and its application, Heisenberg Uncertainty principle, Pauli exclusion principle to understand the basics.
CLO3: Apply the concept on different types of problems such as 1D box, harmonic oscillator, hydrogen atom, etc.
CLO4: Analyze the concept to evaluate the eigenvalues and eigenfunction of different molecular structures.

Syllabus

Unit	Content	Hours
Unit I: Linear Vector Space and Structure of Quantum Chemistry	Linear vector space, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, rules of differentiation, applications of differential calculus, application of integral calculus, Dirac notations of Bra - Ket notation, the postulates of quantum mechanics Operators and observables, operators as matrices, significance of eigenvalues and eigenfunctions, Commutation relations, Uncertainty principle.	**15**
Unit II: Schrödinger Equation and 1D Problems	The Schrodinger equation to some model system- particle in a box, the Harmonic oscillator, the rigid rotator, the hydrogen atom, Angular momentum: ordinary angular momentum, generalized angular momentum, Eigen functions for angular momentum, eigenvalues of angular momentum, operator using ladder operators.	**15**
Unit-III: Spherically Symmetric Potentials	Pauli matrices and spinors, Identical particles: Indistinguishability, symmetric and antisymmetric wave functions, incorporation of spin, Pauli exclusion principle. Born-Oppenheimer approximation, VB and MO theory, H_2+, H_2 molecule problem, Hückel molecular orbital theory and its application to ethylene, butadiene and benzene. Hybridisation and valence MOs of H_2O, NH_3 and CH_4. Introduction to the SCF.	**15**

Reading references:

1. P. Tebbutt. *Basic Mathematics for Chemists*. Wiley, New York. 1998, 2nd Ed.
2. B. Singh. *Mathematics for Chemists*. Pragati Prakashan, Meerut. 2015, 1st Ed.
3. I. N. Levine. *Quantum Chemistry*. Tata McGraw-Hill Publishing Company Ltd., New Delhi. 2002, 5th Ed.
4. A. K. Chandra. *Introductory Quantum Chemistry*. Tata McGraw-Hill Publishing Company Ltd., New Delhi. 1995, 4th Ed.
5. H. C. Verma. *Quantum Physics*. Surya Publications, Ghaziabad. 2009, 2nd Ed.
6. P. W. Atkins. *Molecular Quantum Mechanics: An Introduction to Quantum Chemistry*. Clarendon Press, Oxford. 1970, 1st Ed.
7. D. A. McQuarrie. *Quantum Chemistry*. University Science Books, Sausalito. 2007, 2nd Ed.

CH4 106: BASIC ORGANIC CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 106	**Course name:** BASIC ORGANIC CHEMISTRY LABORATORY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8 per week	4	120	Lab	CCE, ESE	100	35

Course Objectives:

- To separate and purify mixture of organic acids and bases.
- To understand and apply synthetic planning and experimental execution of one or two step synthesis.
- To characterize the organic compounds by use of various analytical techniques like IR, NMR and mass.

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Describe the separation and purification techniques used in organic synthesis.
CLO2: Illustrate the experimental techniques for one or two step synthesis.
CLO3: Apply chromatographic techniques in monitoring and analyzing reaction progress.
CLO4: Evaluate the analytical techniques line IR and NMR for characterization of products.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To Separate components mixtures (nitrophenols, amines, carboxylic acids, and water-soluble substances)	**12**
2	To synthesize and characterize of m-dinitrobenzene by nitration method	**12**
3	To synthesize and characterize Benzanilide by benzoylation process	**12**
4	To preparation and characterize pyridinium salt	**12**
5	To prepare and characterize Methyl orange by Diazotization	**12**
6	To prepare and characterize aldol condensation product by reaction with benzaldehyde and acetophenone	**12**
7	To prepare and characterize dibenzalacetone	**12**
8	To prepare and characterize benzyl alcohol from benzaldehyde by sodium borohydride	**12**
9	To synthesize and characterize phenylacetic acid by hydrolysis of Benzyl cyanide	**12**
10	To prepare and characterize benzoic acid by oxidation of benzaldehyde	**12**

Reading references:

1. I. Vogel; B. S. Furniss. *Vogel's Textbook of Practical Organic Chemistry*. Longman Scientific & Technical, Essex. 1989, 5th Ed.
2. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry*. Longman Scientific & Technical, London. 1960, 4th Ed.
3. N. K. Vishnoi. *Advanced Practical Organic Chemistry*. Vikas Publishing House, New Delhi. 2010, 3rd Ed.
4. R. K. Bansal. *Laboratory Manual of Organic Chemistry*. New Age International Publishers, New Delhi. 1983, 5th Ed.

CH4 107: INORGANIC CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 107	**Course name:** INORGANIC CHEMISTRY LABORATORY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8 per week	4	120	Lab	CCE, ESE	100	35

Course Objectives: The laboratory course focuses on

- Quantitative analysis by gravimetric method
- Emphasize the principles of different redox titrimetric analyses like a) mermanganometry, b) dichrometry, c) iodometry

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Demonstrate practical execution of redox titrimetric estimations of different metal ions based on a) Permanganometry, b) Dichoromatometry, c) Iodometry
CLO2: Estimation of different ions based on complexometric EDTA titration.
CLO3: Determination of different metal ions quantitively by Gravimetric estimation.
CLO4: Separation of different ions in a mixture like brass or Dolomite by volumetric estimation

Syllabus

Sr. No.	Name of the Experiment	Hours
1.	Estimation of Fe(II) in a given solution (Permanganometry). Estimation of Fe(II) with K_2Cr_2O(dichromatometry/dichrometry).	**15**
2.	Estimation of Cu(II) in a solution (Iodometry). Estimation of total hardness of water using EDTA by complexometric method	**15**
3.	Estimate the amount of magnesium present per liter of the given solution of magnesium sulfate To determine the percentage of iron in hematite ore	**15**
4.	To estimate the mass of nickel in the whole of the given nickel ammonium sulfate solution	**15**
5.	Synthesis and analysis of 3d metal complexes. Synthesis and analysis of rare earth metal complexes	**15**
6.	Gravimetric estimation of Cu from a mixture of Cu and Fe solution. Gravimetric determination of Fe in Fe and Cr solution. Gravimetric determination of Ni in Cu and Ni solution.	**15**
7.	Volumetric estimation of Cu in Cu and Ni (German silver). Volumetric estimation of Ca and Mg in Dolomite solution.	**15**
8.	Volumetric estimation of Fe in Cu and Fe solution. Volumetric estimation of Zn in Brass Volumetric estimation of Ni in Ni and Zn solution.	**15**

Reading references:

1. G. H. Jeffery; J. Bassett; J. Mendham; R. C. Denny. *Vogel's Textbook of Quantitative Chemical Analysis*. Longman Scientific & Technical, Essex. 1989, 5th Ed.
2. G. Svehla. *Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis*. Orient Longman, Hyderabad. 1982, 5th Ed.

SEMESTER II

SYLLABUS WITH COURSE LEARNING OUTCOME (CLO)

CH4 204: ORGANIC CHEMISTRY-II REACTIONS, REAGENTS AND REARRANGEMENTS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** II
Course code: CH4 201	**Course name:** ORGANIC CHEMISTRY-II REACTIONS, REAGENTS, AND REARRANGEMENTS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:
- Develop a mechanistic understanding of redox processes
- Explore the reactivity and synthetic utility of organometallic and selective reagents
- Analyze diverse organic rearrangements and reaction pathways

Course Learning Outcomes: At the end of this course, students will be able to:
CLO1: Explain the mechanisms and stereochemical aspects of organic reactions, including addition, elimination, oxidation, and reduction.
CLO2: Analyze molecular rearrangements and their significance in synthetic organic chemistry.
CLO3: Identify and describe the synthesis, chemical reactions, and properties of heterocyclic compounds.
CLO4: Apply knowledge of reaction mechanisms and heterocyclic chemistry to solve complex problems in organic synthesis.
CLO5: Evaluate the applications of heterocyclic compounds in pharmaceuticals, agrochemicals, and materials science.

Syllabus

Unit	Content	Hours
Unit I: Organic Reaction Mechanisms – Oxidations and Reductions	**Fundamentals of Redox Reactions in Organic Chemistry:** Electron transfer vs. hydride transfer vs. atom transfer; Redox potential and selectivity; **Mechanistic Insights:** Electron flow (arrow-pushing); Stereoselectivity and chemo/regioselectivity; Transition states, intermediates, catalytic cycles **Oxidation Mechanisms:** **Alcohols → Aldehydes/Ketones/Acids**: PCC, PDC, Dess–Martin, Swern, Jones, $KMnO_4$, TEMPO; **Alkenes and Alkynes**: Epoxidation (m-CPBA, peracids), Dihydroxylation (OsO_4, $KMnO_4$), Oxidative cleavage (ozonolysis, $KMnO_4$) **Reduction Mechanisms:** **Carbonyl compounds**: $NaBH_4$, $LiAlH_4$, DIBAL-H; Reductive amination, Birch reduction, Clemmensen, Wolff–Kishner; **Selective reductions**: Rosenmund, Lindlar, Meerwein Ponndorf–Verley **Asymmetric Oxidations and Reductions (Brief Introduction):** Sharpless epoxidation, Corey–Bakshi–Shibata (CBS) reduction	**15**
Unit II: Reagents in Organic Synthesis	Classification of reagents; about air and moisture sensitive reagents; handling, storage and precaution. Reagent role in stepwise mechanism; Stereocontrol and functional group compatibility; Concept of functional group interconversion (FGI); Chemoselectivity, regioselectivity, and protecting group strategies **Organometallic Reagents:** Grignard, organolithium, organocuprates, Gilman reagents Applications in C–C bond formation; Transition-metal catalysts (Pd, Ru, Rh) and other cross-coupling reagents **Hypervalent iodine reagents-** Various types of hypervalent iodine reagents and their preparation; application in organic transformation, selectivity, sensitivity	**15**

	and reactivity; **Peptide couplingreagents** and their applications. **Functional group protecting agents**– Different types of protecting/masking agents; **Selective and Protective Reagents:** Silyl protecting groups (TBDMS, TMS), Acetals, Carbamates, PMP protection and their deprotection after completion of reaction; **Electrophilic halogenating agents** (NBS, NCS), sulfonation, acylation reagents. **Phase-transfer Catalysts**	
Unit III: Molecular Rearrangements	Intramolecular vs. Intermolecular; Pericyclic, ionic, and radical pathways; Rearrangement vs. Isomerization; Importance of Rearrangements in installation of Stereocenters and importance of conformational aspects in this regard **Rearrangements Involving Carbocations:** Wagner–Meerwein, Pinacol–Pinacolone, Tiffeneau–Demjanov Benzilic acid and related 1,2-shifts **Rearrangements Involving Carbanions and Ylides:** Favorskii, Wittig, Stevens, Sommelet–Hauser, Ireland–Claisen **Rearrangements Involving Nitrenes:** Curtius, Hofmann, Lossen, Schmidt, Beckmann **Pericyclic Rearrangements (Concerted):** Cope and Claisen rearrangements; Aza–Claisen, Oxy–Cope, Sigmatropic shifts **Oxidative Rearrangements:** Baeyer–Villiger, Dienone–Phenol rearrangement	**15**

Reading references:

1. R. K. Mackie; D. M. Smith; R. A. Aitken. *Guidebook to Organic Synthesis*. Addison-Wesley Longman Ltd., Harlow. 1990, 2nd Ed.
2. H. O. House. *Modern Synthetic Reactions*. W. A. Benjamin, Menlo Park. 1972, 2nd Ed.
3. M. B. Smith. *Organic Synthesis*. Editorial Staff, Boca Raton. 2016, 4th Ed.
4. S. N. Sanyal. *Reactions, Rearrangements, and Reagents*. Bharti Bhawan Publishers, Patna. 2020, 4th Ed.
5. F. A. Carey; R. J. Sundberg. *Advanced Organic Chemistry: Part A Structure & Mechanism*. Springer, New York. 2007, 5th Ed.
6. R. K. Bansal. *Heterocycles*. New Age International Publishers, New Delhi. 2022, 7th Ed.
7. I. L. Finar. *Organic Chemistry Vol. I & II*. ELBS Publication, London. 2002, 5th Ed.
8. M. C. Ray. *Reaction Mechanisms in Organic Chemistry*. MTG Learning Media, New Delhi. 2021, Revised Ed.
9. J. J. Li. *Name Reactions*. Springer, New York. 2018, 4th Ed.
10. C. M. Rojas. *Molecular Rearrangements in Organic Synthesis*. Wiley, Hoboken. 2015, 1st Ed.
11. R. K. Bansal. *Organic Reaction Mechanisms*. New Age International, New Delhi. 2012, 4th Ed.
12. J. March. *Advanced Organic Chemistry*. Wiley India Pvt. Ltd., New Delhi. 2007, 6th Ed.
13. L. M. Harwood. *Advanced Organic Chemistry*. Oxford University Press, Oxford. 1992, 1st Ed.
14. P. S. Kalsi. *Organic Reactions and Their Mechanisms*. New Age International, New Delhi. 2020, 3rd Ed.
15. R. M. Acheson. *An Introduction to the Chemistry of Heterocyclic Compounds*. Wiley Student Edition, New York. 2008, 3rd Ed.
16. J. A. Joule; K. Mills. *Heterocyclic Chemistry*. Wiley, Chichester. 2010, 5th Ed.
17. T. L. Gilchrist. *Heterocyclic Chemistry*. Pearson Education, Harlow. 2005, 3rd Ed.
18. R. R. Gupta; M. Kumar; V. Gupta. *Heterocyclic Chemistry*. Springer, Berlin. 1998, 1st Ed.

CH4 202: INORGANIC CHEMISTRY-II MAIN GROUP AND ORGANOMETALLIC COMPOUNDS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** II
Course code: CH4 202	**Course name:** INORGANIC CHEMISTRY-II MAIN GROUP AND ORGANOMETALLIC COMPOUNDS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Description:

- This course deals with the understanding of different periodic properties and periodic anomalies.
- This course provides a detailed study of s- and p-block group elements. This course also focuses on EAN rule and various Carbonyl, nitrosyl metal complexes.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Define periodic properties and anomalies
CLO2: Elaborate discussion of s &p-block ~~group~~ (1-2 &13-18) elements
CLO3: Calculate the EAN value of different organometallic compounds
CLO4: Summarize bonding, structure and property of different carbonyl-nitrosyl compounds

Syllabus

Units	Content	Hours
Unit I: Periodic trends, structure, bonding	Periodic Trend: Radius, Ionization enthalpy, electron gain enthalpy, electronegativity. Relativistic effects on chemical properties. Hydrogen and its compounds: H-bond and its influence on the structure and properties of crystals Hydrides, classification: electron deficient, electron precise and electron rich hydrides. Concept of ortho and para hydrogen, Alkali and alkaline earth metals: Solutions in liquid ammonia - Synthesis, properties, uses and structures of crown ether complexes, **Group 13 elements:** Borides, borates, boron halides, boranes, carboranes and metallocarboranes, BN compounds, transition-metal stabilized borylene and boryllithium, organoaluminum compounds, Lewis Base adducts of AlR3 compounds, Subvalent organo-Al compounds, Organo-gallium, -indium, and –thallium compounds. **Group 14 elements:** Allotropes of Carbon- C60 and its compounds (fullerenes) - carbon nanotubes: synthesis and properties - Intercalation compounds of graphite - Pure Silicon, silica and silicates, Silicones – Low coordinated and hypervalent Silicon compounds - Brief survey of Ge, Sn, and Pb chemistry- Organo-germanium, -tin, and -lead compounds **Group 15 elements:** P(V) compounds (structure, bonding, reactivity)-P(III) compounds: diphosphenes, phosphaalkenes, iminophosphanes - P-containing ring systems (phosphabenzene, phosphole), phosphazenes, Oxo-acids of Phosphrous. Comparison of basicity, reducing property of oxoacids. **Group 16 elements**: Sulfurpolycationic and anionic species - SN compounds.	**15**
Unit II: Halogens and Nobel gases	**Group 17 elements:** Charge-transfer complexes of halogens, inter-halogen compounds, halogen oxides and oxygen fluorides, pseudo halogens. **Group 18 elements:** Physical properties and reactivity, Xenon compounds: preparation, bonding and structure, noble gas clathrates	**15**
Unit III: Metal carbonyl and nitrosyl complexes	**Organometallic Chemistry:** Complexes with pi-acceptor and sigma-donor ligands - 16 electron and 18 electron rules– Stability and Reactivity - Isolobal analogy, synergic effect, preparation, Structure, and property ~~and bonding~~ of carbonyl and nitrosyl compounds, evidence for multiple bonds in Carbonyl	**15**

	compounds, nature of bonding, stretching frequency and ligand effect, Roussin's salt- Metal carbenes and metal carbynes, Ferrocene.	

Reading references:

1. A. G. Massey. *Main Group Chemistry*. Wiley, Chichester. 2000, 2nd Ed.
2. N. N. Greenwood; A. Earnshaw. *Chemistry of the Elements*. Pergamon Press, Oxford. 1989, 1st Ed.
3. P. Atkins; T. Overton; J. Rourke; M. Weller; F. Armstrong. *Shriver and Atkins' Inorganic Chemistry*. W. H. Freeman and Company, New York. 2009, 5th Ed.
   or
   D. F. Shriver; P. W. Atkins. *Inorganic Chemistry*. W. H. Freeman and Company, New York. 1999, 3rd Ed.
4. C. Housecroft; A. G. Sharpe. *Inorganic Chemistry*. Prentice Hall/Pearson Education, Harlow. 2008, 3rd Ed.
   or
   C. Housecroft; A. G. Sharpe. *Inorganic Chemistry*. Prentice Hall/Pearson Education, Harlow. 2012, 4th Ed.
5. F. A. Cotton; G. Wilkinson. *Advanced Inorganic Chemistry*. John Wiley & Sons, New York. 1988, 5th Ed.
   or
   F. A. Cotton; C. A. Murillo; M. Bochmann; R. N. Grimes. *Advanced Inorganic Chemistry*. John Wiley & Sons, New York. 1999, 6th Ed.
6. J. E. Huheey; E. A. Keiter; R. L. Keiter. *Inorganic Chemistry: Principles of Structure and Reactivity*. Prentice Hall, New Jersey. 1997, 4th Ed.

CH4 203: PHYSICAL CHEMISTRY-II: SURFACE AND INTERFACIAL CHEMISTRY (L-T-P-C: 3-0-0-3)

Program: M.Sc. Chemistry	**Semester:** II
Course code: CH4 203	**Course name:** PHYSICAL CHEMISTRY-II SURFACE AND INTERFACIAL CHEMISTRY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- Understand the principles of surface and interfacial phenomena.
- Apply electrochemical theories and models,
- Evaluate the mechanisms of heterogeneous surface reactions.
- Gain familiarity with modern characterization techniques

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Explain the fundamental principles of surface interactions, including adsorption, surface energy, and surface phenomena, and their role in chemical and physical processes.

CLO2: Apply surface science concepts to analyze and solve problems in catalysis, material design, and energy systems.

CLO3: Apply electrochemical concepts to analyze and solve problems related to energy storage systems, corrosion, and industrial electrochemical applications.

CLO4: Explain the fundamental principles of catalysis, including reaction mechanisms, catalyst types, and factors influencing catalytic efficiency.

Syllabus

Units	Content	Hours
Unit I: Surface Sciences	Adsorption – surface tension, capillary action pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, Langmuir and Freundlich Adsorption Isotherms, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), Catalytic activity at surfaces. Micelles- Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation, solubilisation, micro emulsion, reverse micelles. Industrial relevance in cosmetics, food science, and detergents.	**15**
Unit II: Electrochemical Interfaces and Applications	Electrochemistry of solutions. Debye-Hückel-Onsager treatment and its extension, ion-solvent interactions, Debye-Hückel-Jerum model. Thermodynamics of electrified interface equations, derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces- Guoy-Chappman, Stern, Graham-Devanathan-Mottwatts models. Polarography theory- Ilkovic equation, half-wave potential, and its significance. Introduction to corrosion, homogeneous theory, forms of corrosion monitoring, and prevention methods. Introduction to Electrochemical Sensors and Biosensors, concepts of amperometric, potentiometric, and voltammetric sensors.	**15**
Unit III: Heterogeneous Catalysis	Mechanism of surface reactions. Surface heterogeneity, activity and selectivity, deactivation, and regeneration. Theories of promotion and poisoning of catalysts. Zeolites and zeolite-like materials, Common synthesis. Characterization of catalysts: Surface area, pore size distribution (mercury porosimetry) Thermal methods (DTA, TG, TPD, and TPR), Surface acidity, DRIFTS, Photoelectron spectroscopy (XPS, AES, XRF, LEED, Mossbauer spectroscopy, SIMS, Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM). Catalysis in Green Chemistry and Sustainability. Nano-catalysis: Role of Particle Size, Shape, and Support Effects at the Nanoscale	**15**

Reading references:

1. M. J. Schick. *Non-ionic Surfactants*. Surfactant Science Series, Marcel Dekker, New York. 1985, Vol. 72.
2. P. Ghosh. *Colloids and Interface Science*. PHI Learning Pvt. Ltd., New Delhi. 2009, 1st Ed.
3. M. J. Rosen. *Surfactants and Interfacial Phenomena*. John Wiley & Sons, New Jersey. 2004, 3rd Ed.
4. M. R. Porter. *Handbook of Surfactants*. Chapman and Hall, London. 1994, 2nd Ed.
5. A. W. Adamson. *Physical Chemistry of Surfaces*. John Wiley & Sons, New York. 1997, 6th Ed.
6. J. O'M. Bockris; A. K. N. Reddy. *Modern Electrochemistry, Vol. II*. Springer, New York. 2018, 2nd Ed.
7. A. Tager. *Physical Chemistry of Polymers*. Mir Publishers, Moscow. 1978, 1st Ed.
8. H. S. Harned; B. B. Owen. *The Physical Chemistry of Electrolytic Solutions*. Reinhold Publishing, New York. 1950, 1st Ed.
9. S. Glasstone. *Textbook of Physical Chemistry*. Macmillan Publishers, London. 1948, 2nd Ed.

CH4 204: BIOORGANIC CHEMISTRY (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** II
Course Code: CH4 204	**Course name:** BIOORGANIC CHEMISTRY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- To understanding the role of biological molecules used in daily life.
- To know and analyze the structure and function of proteins and carbohydrates.
- To discuss the structure, synthesis and application of nucleic acids, lipids and enzymes.

Course Learning Outcomes: At the end of this course, students will be able to

CLO1: Understand the structure and classification of proteins, lipids, carbohydrates and nucleic acid.

CLO2: Learn various structural determination techniques of biomolecules.

CLO3: Apply the knowledge of biomolecules in the progression of diseases.

CLO4: Demonstrate the role of biomolecules in drug discovery and development.

Syllabus

Units	Content	Hours
Unit I: Protein and Carbohydrates	Peptides and Proteins: Building blocks to the Quaternary structure of proteins, structure-stabilizing interactions in secondary structures. α-helix, β-sheets, secondary structures, triple helix structure of collagen. Tertiary structure of protein-folding and domain structure, Peptidomimetics, Carbohydrates: Classification and structure of simple and complex carbohydrates. Structure and function of the most important carbohydrates Structural polysaccharides-cellulose and chitin. Storage polysaccharides-starch and glycogen. Structure and biological function of glucosaminoglycans or mucopolysaccharides.	**15**
Unit II: Nucleic Acids and Lipids	**Nucleic Acids:** Detailed Structure of nucleic acids, Different types of DNA, the double helix model of DNA, and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. Chemical synthesis of mono and tri-nucleosides. The chemical basis for heredity, an overview of replication of DNA, transcription, translation, and genetic code, Nucleic Acids as Therapeutic Targets. **Lipids:** Classification, chemical structure, and biological functions of lipids, glycerol phospholipids, sphingolipids, cholesterol, bile acids, prostaglandins, Lipoproteins-composition and function, role in atherosclerosis. Properties of lipid aggregates-micelles, bilayers, liposomes, and their possible biological function.	**15**
Unit III: Enzymes	Enzymes, Coenzymes, enzyme-kinetics, metalloenzymes, applications of enzymes in organic synthesis, enzyme-models and applications. Enzyme-catalyzed carboxylation and decarboxylation reactions. Enzyme inhibition and drug design, Molecular recognition, chiral recognition, crown ethers, cryptands, host-guest chemistry.	**15**

Reading references:

1. L. Lehninger. *Principles of Biochemistry*. Worth Publishers, New York. 2007, 7th Ed.
2. L. Stryer. *Biochemistry*. W. H. Freeman and Company, New York. 2019, 5th Ed.
3. D. Voet; J. G. Voet. *Biochemistry*. John Wiley & Sons, New York. 2010, 3rd Ed.
4. J. L. David; J. Rawn. *Biochemistry*. Neil Patterson Publishers, North Carolina. 1989, International Ed.
5. E. E. Conn; P. K. Stumpf. *Outlines of Biochemistry*. John Wiley & Sons, New York. 2006, 5th Ed.
6. T. Palmer. *Understanding Enzymes*. Prentice Hall, London. 1995, 2nd Ed.
7. C. H. Collins; J. Suckling. *Enzyme Chemistry: Impact and Applications*. Chapman and Hall, London. 1990, 2nd Ed.
8. U. Satyanarayana; U. Chakrapani. *Essentials of Biochemistry*. Elsevier Health Sciences, New Delhi. 2021, 3rd Ed.
9. R. K. Murray; V. W. Rodwell; D. Bender; K. M. Botham; P. A. Weil; P. J. Kennelly. *Harper's Illustrated Biochemistry*. McGraw Hill Professional, New York. 2009, 28th Ed.

CH4 205: SPECTROSCOPY-I: MOLECULAR STRUCTURE ELUCIDATION (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** II
Course Code: CH4 205	**Course name:** SPECTROSCOPY-I: MOLECULAR STRUCTURE ELUCIDATION

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Description:
Understand the principles, instrumentation, and interpretive strategies of UV-Vis, IR, NMR (^{1}H and ^{13}C), and mass spectrometry
Correlate spectral data with molecular structure and functional groups
Apply spectroscopic techniques to differentiate isomers, elucidate structures, and analyze mixtures

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Remember the basic concept of Vibrational, UV, IR, 1H and Mass spectroscopy
CLO2: Understand the concept of vibrational frequency in IR, chemical shift in NMR, fragmentation pattern in Mass spectrometry
CLO3: Apply the knowledge for structure elucidation of organic compounds.
CLO4: Analyze the UV, IR,^{1}H NMR and Mass spectra

Syllabus

Units	Content	Hours
Unit I: UV and IR Spectroscopy	**UV, and IR Spectroscopy –** **UV Spectroscopy:** Origin of electronic spectra, Lambert-Beer's absorption law, Types of electronic transitions. Principle of UV spectroscopy and instrumentation. Effect of solvent, substituent, and conjugation on electronic transitions. Factors affecting the position and intensity of bands and λmax, Chromophores and auxochromes, Benzene and its substituted derivatives. Applications of UV-visible spectroscopy in analysis (qualitative/quantitative) of polyenes/aromatic (hetero & homo) systems, geometrical isomers, keto-enol tautomer's, components of a mixture. Woodward-Fieser rules for calculating absorption maximum in dienes, trienes, α, β-unsaturated carbonyl compounds and aromatic compounds. Application of UV spectroscopy **IR Spectroscopy:** Instrumentation–sources-sampling techniques. Factors influencing IR spectroscopy, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. Differentiation of compounds/isomers by IR. Application of IR spectroscopy and limitations.	**15**
Unit II: NMR Spectroscopy	**^{1}H NMR Spectroscopy**: Introduction, Definition, Chemical shift and factor affecting chemical shift, spin-spin interaction, shielding and deshielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, carbonyl and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), coupling constants – vicinal, geminal, long range and virtual couplings, Intensity of signal (Peak area or integration) the effect of deuteration, complex spin-spin interaction between two, three nuclei. Stereochemistry, hindered rotation, Karplus curve variation of coupling constant with dihedral angle.	**15**

	^{13}C NMR Spectroscopy:^{13}C NMR, introduction to FT technique, relaxation phenomena, NOE effects, ^{1}H and ^{13}C chemical shifts to structure correlations. Chemical shift and (Aliphatic, olefinic, Alkyne, Aromatic, Heteroaromatic and carbonyl carbon), Coupling constants. To identify structure from ^{13}C NMR data; Use of ^{13}C spectra in differentiating compounds/isomers. Difference between ^{1}H NMR and ^{13}C NMR	
Unit III: Mass Spectrometry	**Mass Spectrometry -** Origin of mass spectrum, principles of EI mass spectrometer-Instrumentation. Preliminary account of chemical ionization, Types of fragments: odd electron and even electron containing neutral and charged species (even electron rule, Nitrogen rule, isotopic peaks, metastable ion peaks, determination of molecular formula and High-resolution mass spectrometry. Salient features of the fragmentation pattern of organic compounds- α-cleavage, β cleavage, McLafferty rearrangement, the Fragmentation pattern of individual heterocyclic systems viz., Furan, Pyrrole, Thiophene and Pyridine.	**15**

Reading references:

1. C. N. Banwell; E. M. McCash. *Fundamentals of Molecular Spectroscopy*. McGraw-Hill Education, New Delhi. 2011, 4th Ed.
2. G. Aruldhas. *Molecular Structure and Spectroscopy*. Prentice Hall of India, New Delhi. 2004, 2nd Ed.
3. R. M. Silverstein; F. X. Webster; D. J. Kiemle; D. L. Bryce. *Spectroscopic Identification of Organic Compounds*. John Wiley & Sons, New York. 2014, 8th Ed.
4. Y. R. Sharma. *Elementary Organic Spectroscopy*. S. Chand & Company Ltd., New Delhi. 2007, Revised Ed.
5. R. Kakkar. *Atomic and Molecular Spectroscopy*. Cambridge University Press, Cambridge. 2015, 1st Ed.
6. W. Kemp. *Organic Spectroscopy*. Macmillan, London. 1994, 3rd Ed.
7. D. H. Williams; I. Fleming. *Spectroscopic Methods in Organic Chemistry*. McGraw-Hill Education, London. 1995, 5th Ed.
8. A. B. Derome. *Modern NMR Techniques for Chemistry Research*. Pergamon Press, Oxford. 1987, Reprinted Ed.
9. D. L. Pavia. *Introduction to Organic Spectroscopy*. Cengage India Pvt. Ltd., New Delhi. 2015, 5th Ed.
10. G. C. Levy; O. L. Nelson. *Carbon-13 NMR for Organic Chemists*. Wiley, New York. 1980, 2nd Ed. and
    Atta-ur-Rahman. *Nuclear Magnetic Resonance: Basic Principles*. Springer-Verlag, New York. 2011, 1st Ed.
11. P. S. Kalsi. *Spectroscopy of Organic Compounds*. New Age International Pvt. Ltd., New Delhi. 2020, 8th Ed.

CH4 206: ANALYTICAL TECHNIQUES LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry	**Semester:** II
Course code: CH4 206	**Course name:** ANALYTICAL TECHNIQUES LABORATORY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8 per week	4	120	Lab	CCE, ESE	100	35

Course Objectives:

- To understand and learn analytical techniques in biochemical studies.
- To separate and identify biomolecules such as amino acids, carbohydrates, and proteins.
- To determine the iodine value of lipids
- To determine the concentration of biomolecules in tea and coffee

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Demonstrate proficiency in techniques for the separation and identification of biomolecules, including amino acids and sugars.
CLO2: Quantify biomolecules using standard methods like Anthrone and Lowry's techniques.
CLO3: Evaluate lipid properties through determination of iodine and acetyl numbers.
CLO4: Analyze organic compounds using spectroscopic methods, including UV-visible and IR spectroscopy.
CLO5: Compare and interpret shifts in electronic absorption spectra under varying chemical conditions.

Syllabus

Sr. No.	Name of the Experiment	Hours
1.	Determination of Isoelectronic point (PI) of Amino acid by titration method.	**8**
2.	Characterize mono- and disaccharides by recrystallization, solubility, melting points, and crystal morphology.	**8**
3.	Estimation of total sugar in biological samples using the Anthrone method involving spectrophotometric detection.	**8**
4.	Estimation of amino acids using Ninhydrin-Anthrone method involving colorimetric analysis.	**8**
5.	Estimation of protein by Lowery's method	**8**
6.	Determination of Iodine number and acetyl number of Lipid molecules.	**8**
7.	Separation of amino acids by paper chromatography	**8**
8.	Study the bathochromic shift of p-nitrophenol in UV-Vis spectra under alkaline vs. neutral conditions to assess pH-dependent resonance effects.	**8**
9.	Study the hypsochromic shift in aniline by comparing its UV-Vis spectra in neutral and acidic media.	**8**
10.	Compare IR spectra of acetone and benzophenone to distinguish aliphatic and aromatic ketones based on key vibrations.	**8**
11.	Comparative IR Analysis of Aromatic and aliphatic Nitro compounds, Amines, Nitriles and Amides	**8**
12.	Analyze unknown organic samples to identify alcohols, acids, amines, or esters based on diagnostic IR bands	**8**
13.	UV- Vis Spectrophotometric Analysis of caffeine and benzoic acid in soft drinks via Beer's Law.	**8**
14.	Assign ^{1}H NMR peaks of common compounds using chemical shift, splitting, and integration with software or spectra.	**8**
15.	Record and analyze spectra of complexes like $[Cu(NH_3)_4]^{2+}$ or $[Fe(SCN)]^{2+}$ to observe d–d transitions and ligand effects.	**8**

Reading references:

1. R. Katoch. *Analytical Techniques in Biochemistry and Molecular Biology*. Springer, New York. 2011, 1st Ed.
2. H. Martin. *Basic Methods for the Biochemical Lab*. Springer, Berlin. 2007, 1st Ed.
3. K. Wilson; J. Walker. *Principles and Techniques in Biochemistry and Molecular Biology*. Cambridge University Press, Cambridge. 2010, 7th Ed.
4. J. A. A. Chambers; D. Rickwood. *Biochemistry Lab Fax*. Blackwell Science, Oxford. 1993, 1st Ed.
5. T. S. Work; E. Work. *Laboratory Techniques in Biochemistry and Molecular Biology, Vol. I & II*. North-Holland Publishing Company, Amsterdam. 1970, 1st Ed.
6. R. K. Bansal. *Practical Organic Chemistry*. New Age International Pvt. Ltd., New Delhi. 2008, 5th Ed.
7. D. Field; S. Sternhell; J. R. Kalman. *Organic Structures from Spectra*. John Wiley & Sons Ltd., Chichester. 2008, 4th Ed.
8. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry*. Pearson Education India, New Delhi. 2009, 4th Ed.
9. W. Kemp. *Organic Spectroscopy*. Macmillan, London. 1994, 3rd Ed.
10. P. S. Kalsi. *Spectroscopy of Organic Compounds*. New Age International Publishers, New Delhi. 2007, 6th Ed.
11. Y. R. Sharma. *Elementary Organic Spectroscopy – Principles and Chemical Applications*. S. Chand & Company Ltd., New Delhi. 1992, 5th Ed.

CH4 207: PHYSICAL CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry	**Semester:** II
Course code: CH4 207	**Course name:** PHYSICAL CHEMISTRY LABORATORY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8 per week	4	120	Lab	CCE, ESE	100	35

Course Objectives:

- Develop proficiency in measurement techniques, including conductometry, potentiometry, viscometry, polarimetry, and pH-metry,
- Apply experimental methods to determine key physical and chemical constants, such as rate constants, activation energies, dissociation constants, solubility products, redox potentials, and molecular weights.
- Analyze thermodynamic and kinetic behavior of systems involving acid-base equilibria, micellization, protein denaturation, complex formation, and polymer solutions through laboratory investigations.
- Interpret experimental data using modern instrumental techniques and relate them to theoretical models in physical chemistry.

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Learn the science of buffer preparation, highlighting the theories of ionic equilibrium
CLO2: Perform experiments to determine reaction rates and rate constants for chemical reactions using appropriate laboratory techniques.
CLO3: Conduct equilibrium experiments to determine equilibrium constants and verify Le Chatelier's principle
CLO4: Learn graph plotting and data interpretation.
CLO5: Demonstrate proficiency in laboratory practices, including accurate measurements, data recording, and safety protocols

Syllabus

Sr. No.	Name of the Experiment	Hours
1.	Conductometric Determination of the Percentage Composition of Strong and Weak Acids in a Mixture	**8**
2.	Conductometric Determination of the Rate Constant and Activation Energy for the Hydrolysis of Methyl Acetate	**8**
3.	To determine the relative strengths of the given strong acids by studying the kinetics of inversion of cane sugar using the polarimetric method.	**8**
4.	Determination of the Viscosity Average Molecular Weight of a Polymer Using Ostwald's Viscometer	**8**
5.	To determine the Redox potential of Fe2+/ Fe3+ system by potentiometric method. (pH metry) Or, Potentiometric Determination of KCl and KI Concentrations in a Mixture Using Standard $AgNO_3$ Solution	**8**
6.	Potentiometric Determination of the Strength of an Unknown Silver Nitrate ($AgNO_3$) Solution	**8**
7.	pH-Metric Determination of the Dissociation Constants (pK_1 and pK_2) of a Dibasic Acid	**8**
8.	Conductometric Determination of the Solubility Product (Ksp) of Barium Sulfate and Silver Chloride.	**8**
9.	Potentiometric Determination of the Dissociation Constants of Monobasic Acids: Acetic Acid, Benzoic Acid, and Salicylic Acid	**8**
10.	Kinetic study of the esterification of an alcohol by NMR Spectroscopy. (Chemical kinetics)	**8**

11.	Determination of Critical Micelle Concentration (CMC) and Thermodynamics of Micellization	**8**
12.	Thermodynamic Study of Protein Denaturation	**8**
13.	Determination of the equilibrium constant for the formation of tri-iodide ion. (Chemical equilibrium)	**8**
14.	Determination of the Thermodynamic Parameters and Equilibrium Constant of a Complex Formation Reaction	**8**
15.	Conductometric Determination of the Critical Micelle Concentration (CMC) of Sodium Dodecyl Sulfate (SDS)	**8**

Reading references:

1. B. D. Khosla; V. C. Garg. *Senior Practical Physical Chemistry*. R. Chand & Co., New Delhi. 2018, 18th Ed.
2. B. Viswanathan; P. S. Raghavan. *Practical Physical Chemistry*. Viva Books Pvt. Ltd., Navi Mumbai. 2017, 1st Ed.
3. A. K. Nad; B. Mahapatra; A. Ghoshal. *An Advanced Course in Practical Chemistry*. New Central Book Agency Pvt. Ltd., Kolkata. 2012, 3rd Ed.
4. J. N. Gurtu; A. Gurtu. *Advanced Physical Chemistry Experiments*. Pragati Prakashan, Meerut. 2008, 1st Ed.

SEMESTER III

SYLLABUS WITH COURSE LEARNING OUTCOME (CLO)

CH5 OR101: ORGANIC CHEMISTRY III (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry (Organic)	**Semester:** III
Course code: CH5 OR101	**Course name:** ORGANIC CHEMISTRY – III: ORGANOMETALLIC CHEMISTRY AND ASYMMETRIC SYNTHESIS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- Understand the fundamental principles of organometallic bonding, reactivity, and catalytic cycles
- Explore the design and application of metal-catalyzed and organocatalytic asymmetric transformations
- Apply retrosynthetic analysis and modern catalytic approaches

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Understand the principles of retrosynthetic analysis in the synthesis of natural product
CLO2: Describe the protection/de-protection strategy in organic synthesis **CLO3:**
Explain the utility of organometallic compounds in fine chemicals **CLO4:**
Demonstrate the various aspects of asymmetric synthesis

Syllabus

Units	Content	Hours
Unit I: Advanced Organometallic Chemistry	A Review of Basics of Bonding in Organometallic Compounds: Definition, classification, and scope of organometallics; 18-electron rule, hapticity Structure, Reactivity & Key Elementary Steps: Synthesis, structures, and bonding in metal carbonyls, cyclopentadienyl and arene complexes; Core reactions: oxidative addition, reductive elimination, migratory insertion, σ-bond metathesis, β-hydride elimination Major Catalytic & Cross-Coupling Reactions: Heck, Suzuki–Miyaura, Stille, Negishi, Sonogashira, Buchwald–Hartwig.Wacker oxidation, Catalytic Activity and usage of Wilkinson's Catalyst, Noyori Catalyst, Knowles Catalysts; Olefin metathesis: RCM by Grubbs 1st, and 2nd generation catalysts Difference between C–H activation C-H Fictionalization: Applications of Organometallic/Palladium catalysis in Organic Synthesis: The power of organometallic Chemistry as a versatile tool in the synthesis of N-acetyl clavicipitic acid methyl ester and building this complex molecule in a short seven-step process.	**15**
Unit II: Asymmetric Synthesis	A Review of Basics & Strategies: Concepts of chirality, stereoselectivity, asymmetric induction (Cram, Felkin, Prelog) Approaches: chiral pool, auxiliaries, substrates, and catalysts Metal-catalyzed Asymmetric Catalysis: asymmetric hydrogenation (olefins, imines), Sharpless epoxidation/diol, Jacobsen, Shi); Shibasaki's heterobimetallic lanthanide-based chiral catalysts. Examples of C–C Bond Forming reactions with Asymmetric Catalysis E.g. Asymmetric aldol, Michael, and Cycloaddition Reactions Resolutions & Kinetic Control: Classical and enzymatic/chemical resolution strategies (KR, DKR, DYKAT) Retrosynthesis & Advanced Topics: Planning chiral strategies: disconnections, chiral auxiliaries, cascade/tandem and polarity inversion using a real synthetic target — viz. (S)-Naproxen, a widely known NSAID (non-steroidal anti-inflammatory drug). Explain how	**15**

	this example integrates: Disconnections, Chiral auxiliaries, Cascade/tandem reactions, and Polarity inversion (umpolung)	
Unit III: Resolution Strategies	Introduction & Activation Modes: Enamine catalysis; Iminium catalysis; Hydrogen-bonding (thioureas, Brønsted acids) Enantioselective Organocatalytic Transformations Aldol & Michael reactions via enamine catalysis; Diels–Alder & epoxidation using iminium/H-bonding catalysts; Transfer hydrogenation with MacMillan catalysts and Hantzsch ester; Kinetic & dynamic resolution: examples in organocatalysis Photoredox organocatalysis combining light and organocatalysts (MacMillan's Innovation)	**15**

Reading references:

1. W. Carruthers. *Modern Methods of Organic Synthesis*. Cambridge University Press, Cambridge. 2004, 4th Ed.
2. R. K. Mackie; D. M. Smith; R. A. Aitken. *Guidebook to Organic Synthesis*. Prentice Hall, Harlow. 1999, 3rd Ed.
3. H. O. House. *Organic Synthesis*. McGraw-Hill Book Company, New York. 1972, 2nd Ed. *(Edition added for completeness - confirm if another is intended)*
4. M. B. Smith. *Organic Synthesis*. Editorial Staff, Boca Raton. 2016, 4th Ed.
5. F. A. Carey; R. J. Sundberg. *Advanced Organic Chemistry: Part A Structure & Mechanism*. Springer, New York. 2007, 5th Ed.
6. M. B. Smith. *Advanced Organic Chemistry*. John Wiley & Sons, Hoboken. 2015, 7th Ed.
7. J. Mann; R. S. Davidson; J. B. Hobbs. *Natural Products: Chemistry and Biological Significance*. Longman Group, Harlow. 1994, 1st Ed.
   and
   I. L. Finar. *Organic Chemistry Vol. 2*. ELBS, London. 1994, 5th Ed. *(clarified from "Vol 2")*
8. M. Nógrádi. *Stereoselective Synthesis: A Practical Approach*. Wiley-VCH Verlag GmbH, Weinheim. 1994, 2nd Ed.
9. Atta-ur-Rahman; M. I. Choudhary. *New Trends in Natural Product Chemistry*. Harwood Academic Publishers, Amsterdam. 1986, 2nd Ed.

CH5 OR102: ORGANIC CHEMISTRY – IV: CHEMISTRY OF NATURAL PRODUCTS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 OR102	**Course name:** ORGANIC CHEMISTRY – IV: CHEMISTRY OF NATURAL PRODUCTS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- To know and understand concept of retrosynthetic analysis.
- To know and study structure and synthesis of terpenoids and alkaloids.
- To utilize the knowledge of natural products in industrial processes.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Explain sources and uses of natural products
CLO2: Classify vitamins with their biochemical synthesis
CLO3: Apply the knowledge of terpenoids and alkaloids in organic synthesis
CLO4: Analyze complex synthesis of steroids

Syllabus

Units	Content	Hours
Unit I: Retrosynthetic Analysis	**Retrosynthesis:** Introduction, Various Terms such as, Retrosynthesis, Target molecule Disconnection, Synthons, Reagents, Synthetic equivalents. One and two functional group C-C & C-X disconnections, Criteria for selection of target molecule, Functional group interconversion, Synthetic tree, Latent polarity, Linear and convergent synthesis. Disconnections in aromatic systems, Retrosynthetic analysis involving chemo-, regio- and stereoselectivities. Umpolung in organic synthesis. Application of the basic concepts for retrosynthetic strategy and synthesis of the following – (S) Propanediol, (R) and (S) – Epichlorohydrin, L (+)- Alanine, (-) Multistratin, (-) Pentenomycin, S-Ibuprofen, S-Metaprolol,	**15**
Unit II: Terpenoids and Alkaloids	**Terpenoids:** Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis, and synthesis of the following representative molecules: Citral, Menthol, Santonin, and B-Carotene. Alkaloids: Definition, nomenclature, and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis, and biosynthesis of: Ephedrine, (+)-Nicotine, and Morphine.	**15**
Unit III: Steroids and Prostaglandins	**Steroids and Prostaglandins:** Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Bileacids, Estrone, Biosynthesis of steroids. **Prostaglandins:** Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE2 and PGF2 a. Synthesis and reactions of Pyrethroids and Rotenones.	**15**

Reading references:

1. J. Mann; R. S. Davidson; J. B. Hobbs. *Natural Products: Chemistry and Biological Significance*. Longman Group, Harlow. 1994, 1st Ed. and
   I. L. Finar. *Organic Chemistry, Vol. 2*. ELBS, London. 1994, 5th Ed.
2. I. L. Finar. *Organic Chemistry, Vol. 2*. Pearson Education, New Delhi. 2022, 6th Ed.
3. K. Hostettmann (Ed.); M. P. Gupta; A. Marston. *Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas*. Harwood Academic Publishers, Amsterdam. 1999, 1st Ed.
4. Atta-ur-Rahman; M. I. Choudhary. *New Trends in Natural Product Chemistry*. Harwood Academic Publishers, Amsterdam. 1986, 2nd Ed.
5. B. G. Torssell. *Natural Product Chemistry: A Mechanistic, Biosynthetic and Ecological Approach*. Swedish Pharmaceutical Press, Stockholm. 1997, 1st Ed.
6. V. Sujata; B. A. Bhat; S. Nagasampagi; S. Meenakshi. *Natural Products: Chemistry and Applications*. Narosa Publishing House, New Delhi. 2011, 1st Ed.
7. O. P. Agarwal. *Organic Chemistry: Natural Products, Volume II*. Krishna Prakashan Media Pvt. Ltd., Meerut. 2011, 1st Ed.

CH5 OR103: ORGANIC CHEMISTRY – V: PERICYCLIC REACTIONS AND ORGANIC PHOTOCHEMISTRY (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 OR103	**Course name:** ORGANIC CHEMISTRY – V: PERICYCLIC REACTIONS AND ORGANIC PHOTOCHEMISTRY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- The course deals with the understanding of the concept of aromaticity, pericyclic, and photochemistry.
- The course also covers various pericyclic reactions, applications of free radicals, and photochemistry of organic compounds.
- Students will learn the difference between Norish type 1 and Norish type II reaction
- The course will cover important name reactions of pericyclic, photochemistry

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Understand the advanced knowledge of aromaticity and pericyclic reactions
CLO2: Describe the concept of FMO, PMO, and Woodward-Hoffman selection rules
CLO3: Explain the applications of ORD and CD
CLO4: Analyze the various photochemical reactions with the mechanism

Syllabus

Units	Content	Hours
Unit I: Pericyclic Reactions	**Pericyclic Reactions:** Aromaticity: Concept of aromaticity, non-aromaticity and anti- aromaticity, Huckel's rule and its applications to simple and non-benzenoid aromatic compounds. Introduction and classification of pericyclic reactions, Orbitals, molecular orbital symmetry, molecular orbital of ethylene, 1,3-butadiene, 1,3,5–hexatriene and allyl systems, FMO Approach, Woodward-Hoffman correlation diagram method and PMO approach for pericyclic reactions under thermal and photochemical conditions. **Electrocyclic Reaction**: concerted reactions, Conrotatory and disrotatory motion, 4n and (4n+2) systems for ring opening and ring closure, **Cycloaddition Reaction:** [2+2] and [4+2] cycloaddition reaction, selection rules through construction of correlation diagrams for cycloaddition reactions and electrocyclic reactions with 4n and 4n+2 π electrons, Cycloaddition of ketones, supra facial and antara facial cycloadditions. Secondary effects in [4+2] cycloaddition. Stereochemical effects on rate of cycloaddition reaction, Diels-Alder reaction, 1,3-dipolar cycloaddition, Cheletropic reaction, the Nazarov reaction. 2s+2a cycloaddition of ketenes. **Sigmotropic Rearrangement**: Suprafacial and antarafacial shift involving H and carbon moieties, Retention and inversion of configuration, [3,3]-, [1,5]-, [2,3] and [5,5]-Sigma tropic rearrangements, Claisen rearrangements (including Aza-Claisen, Ireland-Claisen), Cope rearrangements (including Oxy-Cope, Aza-Cope), Sommelet-Hauser rearrangements, Group transfer reaction, Ene reaction.	**20**

Unit II: Free Radicals and Photochemistry	**Free Radicals and Photochemistry:** **Introduction to Photochemistry and Photophysical Processes:** Formation, stability and detection of short- and long-lived free radicals, homolysis, addition and rearrangements and cyclisation of free radicals and their applications. 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. **Photochemical Reaction**: Photochemistry of carbonyl compounds: $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transitions, Norrish I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction. **Photochemistry of olefins:** Cis-trans isomerization, dimerizations, hydrogen abstraction, addition and Di- π- methane rearrangement including aza-di- π -methane. Photochemical Cross-Coupling of Alkenes, Photodimerization of alkenes. **Photochemistry of arenes:** 1, 2, 1, 3 and 1, 4 additions. Photocycloadditions of aromatic Rings. Singlet oxygen and photo-oxygenation reactions. Applications of photochemical reactions in organic synthesis and natural product synthesis.	**20**
Unit III: ORD and CD, Polarimetry	**ORD and CD, Polarimetry:** Absorption and Dispersion, Optical Rotatory Dispersion and Circular Dichroism (ORD and CD) spectroscopy, underlying principle, circular birefringence, Plane curves, Cotton effects, octant rule, axial halo-keto rule, applications to assignment of configuration of chiral molecules. ORD and CD in determining the absolute configuration of Metal complex.	**5**

Reading references:

1. J. Singh. *Photochemistry and Pericyclic Reactions*. New Age International (P) Ltd., Publishers, New Delhi. 2009, 3rd Ed.
2. F. A. Carey; R. J. Sundberg. *Advanced Organic Chemistry: Part A – Structure and Mechanisms*. Springer, New York. 2008, 5th Ed.
3. K. K. Rohatgi-Mukherjee. *Fundamentals of Photochemistry*. New Age International, New Delhi. 2018, 3rd Ed.
4. R. B. Woodward; R. Hoffmann. *The Conservation of Orbital Symmetry*. Academic Press, New York. 2013, 1st Ed.
5. P. S. Kalsi. *Organic Reactions and Their Mechanisms*. New Age International, New Delhi. 2020, 3rd Ed.
6. W. Carruthers. *Modern Methods of Organic Synthesis*. Cambridge University Press, Cambridge. 2004, 4th Ed.
7. A. Lehr; B. Merchand. *Pericyclic Reactions: A Problem-Solving Approach*. Academic Press, London. 2015, Illustrated Ed.
8. J. Mohan. *Organic Spectroscopy: Principles and Applications*. Narosa Publishing House, New Delhi. 2009, 2nd Ed.

CH5 104: SPECTROSCOPY II: ADVANCED NMR AND MOLECULAR SPECTROSCOPY (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 104	**Course name:** SPECTROSCOPY II ADVANCED NMR AND MOLECULAR SPECTROSCOPY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Objectives:

- Students will learn the basic Principles of NMR, ^{13}C NMR, Raman, and Mössbauer spectroscopy.
- Student will learn the Interpretation of first-order and second-order NMR spectra and methods for their simplification.
- The course will cover the analysis and structure elucidation of organic compounds using 2D NMR techniques.
- Students will learn the fundamentals and applications of rotational and vibrational Raman spectra and mössbauer spectroscopy in chemical analysis.

Course Learning Outcomes: At the end of this course, students will be able to

CLO1: Remember the basic concept of ^{1}H and ^{13}C, Raman and Mossbauer spectroscopy
CLO2: Understand the concept of first and second-order spectra
CLO3: Apply the knowledge for the structure elucidation of an organic compound.
CLO4: Analyze the ^{1}H, ^{13}C NMR, and IR spectra of organic compounds

Syllabus

Units	Content	Hours
Unit I: Proton NMR Spectroscopy	**^{1}H NMR Spectroscopy** -Pople notation and spin assignments; chemical shift equivalence and magnetic equivalence; Differences between first order and Second order effects, examples of AB, AX, A2X2, AX2, AA'XX', AMC and ABX systems, **Simplification of second order spectrum:** selective decoupling, use of chemical shift reagents for stereochemical assignments, Proton exchange, Deuterium exchange, Nuclear Overhauser Effect (NOE); Differentiation of compounds/ isomers by PMR; To identify structure from PMR data, Study of dynamic processes by VT NMR, restricted rotation (DMF, DMA, biphenyls, annulenes), cyclohexane ring inversion, degenerate rearrangements (bullvalene and related systems).	**15**
Unit II: Carbon NMR Spectroscopy	**^{13}C NMR Spectroscopy**- To identify structure from ^{13}C NMR data; Use of ^{13}C spectra in differentiating compounds/isomers; 2D NMR Spectroscopy: Theory and Principles of 2D NMR Spectroscopy (COSY); two-dimensional NMR spectroscopy. COSY, HMBC, HMQC, NOESY. Editing techniques: INEPT and DEPT methods, Time scale- Multinuclear, Introduction to NMR of nuclei other than proton and carbon	**15**
Unit III: Raman and Mossbauer Spectroscopy	**Raman spectroscopy-** Quantum theory of Raman effect, Classical theory of Raman effect, Pure rotational Raman spectra, Raman activity of vibrations, Vibrational Raman spectra, polarization of light and Raman effect, applications., Mutual exclusion principle **Mossbauer Spectroscopy:** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds- nature of M-L bond, coordination number, structure and detection of oxidation state and in equivalent MB atoms. **Raman spectroscopy-** Quantum theory of Raman effect, Classical theory of Raman effect, Pure rotational Raman spectra, Raman activity of vibrations, Vibrational Raman spectra,	**15**

	polarisation of light and Raman effect, applications., Mutual exclusion principle **Mossbauer Spectroscopy:** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds, including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds- nature of M-L bond, coordination number, structure and detection of oxidation state and in equivalent MB atoms.	

Reading references:

1. R. M. Silverstein; G. C. Bassler; T. C. Morrill. *Spectrometric Identification of Organic Compounds*. John Wiley & Sons, New York. 1991, 5th Ed.
2. R. J. Abraham; J. Fisher; P. Loftus. *Introduction to NMR Spectroscopy*. Wiley, Chichester. 1992, 1st Ed.
3. J. R. Dyer. *Application of Spectroscopy of Organic Compounds*. Prentice Hall, Englewood Cliffs, N.J. 1965, 1st Ed.
4. D. H. Williams; I. Fleming. *Spectroscopic Methods in Organic Chemistry*. Tata McGraw-Hill, New Delhi. 1968, 7th Ed.
5. J. L. McHale. *Molecular Spectroscopy*. CRC Press, Boca Raton. 2017, 2nd Ed.
6. D. L. Pavia. *Introduction to Organic Spectroscopy*. Cengage India Pvt. Ltd., New Delhi. 2015, 5th Ed.
7. D. N. S. Narayana. *Handbook of Molecular Spectroscopy*. J. K. International Publishers, New Delhi. 2015, 1st Ed.
8. Y. R. Sharma. *Elementary Organic Spectroscopy*. S. Chand & Company Ltd., New Delhi. 2007, Revised Ed.
9. D. A. Skoog. *Principles of Instrumental Analysis*. Holt Saunders International Edition, New York. 2016, 7th Ed.
10. R. Kakkar. *Atomic and Molecular Spectroscopy*. Cambridge University Press, Cambridge. 2015, 1st Ed.

CH5 105: SPECTROSCOPY ANALYSIS & DATA INTERPRETATION LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry (Analytical)	**Semester:** III
Course code: CH5 105	**Course name:** SPECTROSCOPY ANALYSIS & DATA INTERPRETATION LABORATORY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8 per week	4	120	Lab	CCE, ESE	100	35

Course Objectives:

- The objective of the practical course is to make students understand the spectral analysis of various organic compounds which are synthesized in laboratory and chemical industries.
- Students will also learn various software used in analysis of data in NMR and IR spectroscopy.
- Students will learn structural prediction and confirmation of compounds through their spectral analysis.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Understand the analysis of ^{1}H and ^{13}C-NMR spectra with analysis
CLO2: Explain the IR spectra analysis for functional group determination
CLO3: Apply the knowledge of spectral analysis in structural characterization
CLO4: Demonstrate the application of software for NMR analysis

Syllabus

Sr. No.	Name of the Experiment	Hours
1	Solving structure elucidation problems using multiple spectroscopic data sheets (NMR, MS, IR, and UV-Vis) on at least 20 examples. The elucidation of the chemical structure based on the given spectroscopic data. Students will first calculate the Double bond equivalence based on the given chemical formula. Then, the structural prediction will be made using the provided spectroscopic data (UV, IR, PMR, CMR, and Mass spectra).	**40**
2	Determination of the Effect of alkaline and acidic media on the organic compound using UV-Vis spectroscopy. For example, Determination Bathochromic shift in Alkaline medium of p-Nitrophenol Compared to p-Nitrophenol. Determination of Hypsochromic shift in acidic medium of Aniline compared to Aniline.	**20**
3	Recording the I.R. Spectrum of Different Organic Compounds (i) Aliphatic and aromatic alcohols. (ii) Aliphatic and aromatic carbonyl compounds (aldehydes, ketones, esters, and acids, etc.) Aromatic and aliphatic Nitro, Amines, Nitriles, alkenes, alkynes, and Amides.	**30**
4	Use of computer techniques (i) Chem Draw, Chemsketch, ISIS Draw, Pymol calculations, and MestrecSoftwares operations. (ii) Draw the Structure of Simple aliphatic, aromatic, and heterocyclic compounds in ChemDraw with different substituents. Get the correct IUPAC Name and predict the ^{1}H-NMR Spectra.	**30**

Reading references:

1. R. K. Bansal. *Practical Organic Chemistry*. New Age International Pvt. Ltd., New Delhi. 2008, 5th Ed.
2. D. Field; S. Sternhell; J. R. Kalman. *Organic Structures from Spectra*. John Wiley & Sons Ltd., Chichester. 2008, 4th Ed.
3. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry*. Pearson Education India, New Delhi. 2009, 4th Ed.
4. W. Kemp. *Organic Spectroscopy*. Macmillan, London. 1994, 3rd Ed.
5. P. S. Kalsi. *Spectroscopy of Organic Compounds*. New Age International Pvt. Ltd., New Delhi. 2020, 8th Ed.
6. Y. R. Sharma. *Elementary Organic Spectroscopy – Principles and Chemical Applications*. S. Chand & Company Ltd., New Delhi. 1992, 5th Ed.

CH5 OR106: ADVANCED ORGANIC CHEMISTRY LAB (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry (Organic)	**Semester:** III
Course code: CH5 OR106	**Course name:** ADVANCED ORGANIC CHEMISTRY LAB

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8 per week	4	120	Lab	CCE, ESE	100	35

Course Description:

- This is a practical course which deals with chemical synthesis of various compounds and materials which are synthesized in laboratory and chemical industries.
- This course also explains the various data analysis used in organic synthesis.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Understand the potentiometric analysis of chemical compounds
CLO2: Explain the use of pH meter in sample analysis of acid and base
CLO3: Apply the knowledge of conductometry in analysis of metal complexes
CLO4: Demonstrate the application of polarography and electrogravimetry

Syllabus

Sr. No.	Name of the Experiment	Hours
1	Lab orientation, TLC, melting point, Discussion ofv recrystallization techniques and Introduction of all types of glassware used and their handling Detailed Discussion of all Characterisation Techniques used in Advanced Organic Lab for structural determination (UV-vis, TLC, IR, NMR (Review)	**8**
2	Safety protocols and MSDS preparation for common Organic Reagents Acids, Bases, Salts, Acid Chlorides e.g. SOCl2, fumming liquids like Br2, and Volatile liquids	**8**
3	2-Phenyl indole (Fischer indole synthesis), Benzilic acid from benzoin (Benzilic acid rearrangement)	**8**
4	7-Hydroxy -3-methyl flavone (Baker-Venkatraman reaction), Benzyl alcohol and benzoic acid from benzaldehyde (Cannizzaro reaction)	**8**
5	4-Chlorotoluene from p-toluidine (Sandmeyer reaction) Photochemical reaction: Synthesis of benzopinacol from benzophenone using Sunlight	**8**
6	Diels-Alder reaction: anthracene and maleic anhydride Beckmann rearrangement: Acetanilide from Acetophenone Oxime	**8**
7	Vanillyl alcohol from vanillin ($NaBH_4$ reduction) Stilbene from benzyl chloride (Wittig reaction)	**8**
8	Diphenyl methyl carbinol (Grignard reaction) Cyclohexanol from cyclohexanone (LAH reduction)	**8**
9	Organometallic reactions: Palladium catalyzed cross-coupling reaction	**8**
10	Nitration: Preparation of 2,4-dinitroanisole from anisole, (2) Acytatilation: purification of Acetanilide from aniline,	**8**
11	Halogination: Preparation of p-Bromo Acetanilide from Acetanilide, (4) Coupling reaction: Synthesis of methyl orange,	**8**
12	Synthesis of 4-methyl-7-hydroxycoumarin from resorcinol and ethyl acetoacetate **Click Chemistry**: Cu-catalyzed azide-alkyne cycloaddition	**8**
13	**Azo Coupling**: Methyl orange synthesis **Addition-Elimination Reaction** (e.g., Schiff base from aldehyde & amine)	**8**
14	One-pot synthesis of β-amino carbonyl compounds from formaldehyde, amine, and ketone.	**8**

15	Oxidation of alcohols to carbonyl compounds using selective reagents e.g. using Hypervalent Iodine (Dess–Martin Periodinane)	**8**

Reading references:

1. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry*. Pearson Education India, New Delhi. 2009, 4th Ed.
2. I. Vogel; B. S. Furniss. *Vogel's Textbook of Practical Organic Chemistry*. Longman Scientific & Technical, Essex. 1989, 5th Ed.
3. L. R. Shriner; C. K. Fuson; R. C. Hermann; T. C. Morrill; D. Y. Curtin. *The Systematic Identification of Organic Compounds*. John Wiley & Sons, New York. 2023, 9th Ed.
4. R. M. Silverstein; G. C. Bassler; T. C. Morrill. *Spectrometric Identification of Organic Compounds*. John Wiley & Sons, New York. 1991, 5th Ed.

CH5 EOR1: MEDICINAL CHEMISTRY (L-T-P-C: 2-0-0-2)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 EOR1	**Course name:** MEDICINAL CHEMISTRY

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
8 per week	-	2	30	Lecture	CCE, ESE	50	18

Course Objectives:

- To know various terminologies used in medicinal chemistry.
- To understand the development of drugs and process.
- To discuss anticancer drugs with their mode of action.
- To discuss the design and synthesis of anti-infective drugs such as anti-bacterial and antimalarial.

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Explain process and steps in drug development
CLO2: Classify various diseases and their drugs with mode of action
CLO3: Apply the knowledge of QSAR in discovery of clinical candidates
CLO4: Analyze synthesis and mechanism of action of drugs

Syllabus

Units	Content	Hours
Unit I: Drug and Drug Design	**Drugs:** Classification of drugs; drug targets; Lead discovery; Lead Modification and optimization; Pharmacophore; homologation; bioisostere; chain branching; Electronic effects; Lipophilicity; Structure-Activity Relationships; Quantitative-structure activity relationships (QSAR). Concepts of drug receptors, Elementary treatment of drug-receptor interactions and theories associated with it, Understanding of IC50, MIC, LD50 and ED-50, Concept of prodrugs and soft drugs, isosterism, Bioisosterism, Drug metabolism, (ADMET) Drug like molecules and the recognition of drug like properties.	**10**
Unit II: Anticancer Drugs	**Synthesis and Action of Anti-cancer Drugs:** Introduction and types of cancer, classification of anticancer agents, therapeutic targets for anticancer drugs, role of alkylating agents in treatment of cancer, synthesis use and side effects antineoplastic agents: Mechlorethamine, cyclophosphamide, melphalan, mustards (mode of action) fluorouracil, 6- mercapto purine, recent development in cancer chemotherapy.	**10**
Unit III: Anti-infective Drugs	**Anti-bacterial Drugs:** Introduction and general mode of action of anti-bacterial agents, Synthesis of sulphonamides, norfloxacin, Dapsone, amino salicylic acid, isoniazid, ethionamide, ethamutol. **Anti-malarial Drugs:** Introduction and life cycle of malarial parasites, Mode of action of antimalarial agents SAR of antimalarial agents, Synthesis of 4-amino and 8-amino quinoline, mefloquine chloroquine and primaquine.	**10**

Reading references:

1. A. Gringuage. *Introduction to Medicinal Chemistry: How Drugs Act and Why*. Wiley-VCH, Weinheim. 1996, 1st Ed.
2. Wilson; Gisvold. *Textbook of Organic Medicinal and Pharmaceutical Chemistry*. Lippincott Williams and Wilkins, Philadelphia. 2010, 12th Ed.
3. S. S. Pandeya; J. R. Dimmock. *An Introduction to Drug Design*. New Age International, New Delhi. 1997, 1st Ed.
4. D. J. Abraham. *Burger's Medicinal Chemistry and Drug Discovery, Vol. 1* (Chapters 9 and 14), Ed. M. E. Wolff. John Wiley & Sons, New York. 2003, 6th Ed.
5. L. L. Brunton; B. A. Hilal-Dandan; R. A. Knollmann (Eds.). *Goodman and Gilman's: The Pharmacological Basis of Therapeutics*. McGraw-Hill Education, New York. 2022, 14th Ed.
6. R. B. Silverman. *The Organic Chemistry of Drug Design and Drug Action*. Academic Press, San Diego. 2014, 3rd Ed.

CH5 EOR4: INDUSTRIAL CHEMICAL METHOD AND ANALYSIS (L-T-P-C: 2-0-0-2)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 EOR4	**Course name:** INDUSTRIAL CHEMICAL METHOD AND ANALYSIS

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
2 per week	-	2	30	Lecture	CCE, ESE	50	18

Course Objectives:
- To understand the various industrial chemical processes at pilot scale level.
- To identify chemical hazards and pollutants with their standard operating procedure.
- To understand regulatory guidelines of industrial processes.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Explain the material safety data sheet of chemical compounds
CLO2: Classify various hazardous chemicals and their handling
CLO3: Apply the knowledge in recovery and recycling of various industry chemicals
CLO4: Demonstrate the guidelines and process for setting up small-scale industry

Syllabus

Units	Content	Hours
Unit I: Toxic Chemicals Management	Introduction to toxic and hazardous chemicals, Procedure for working with substances that pose flammable or explosive hazards, Incineration of hazardous chemicals. Identification, classification and segregation of industrial toxic/hazardous chemicals, Recovery, recycling, and reuse of industrially important chemicals	**10**
Unit II: Small Scale Industry and R & D	Need and scope of small scale, Industry, SSI rules and regulations, Registration, Licensing, Incentives, Factory act, Labor laws, FDA, export-import regulations, and tax benefits, Role of R and D, Functional structure of R&D Unit, Research strategies and manufacturing interface	**10**
Unit III: Process Development and Scale-up	Principles of process development: lab to pilot scale; Batch vs. continuous processing: advantages, limitations, and design considerations;Unit operations in chemical industries: mixing, distillation, extraction, drying, and filtration. Process optimization: yield improvement, cost minimization, safety, and sustainability; Reaction engineering basics: heat and mass transfer in industrial reactions; Troubleshooting in scale-up: pressure control, crystallization, impurity handling; Case studies: scale-up of pharmaceutical intermediates, specialty chemicals, and fine chemicals.	**10**

Reading references:

1. R. R. Mukherjee. *Elements of Quality Control*. Vani Educational Books, New Delhi. 1984, 1st Ed.
2. S. K. Tulsi. *Incentives for Small Scale Industries*. ESRS Publications, New Delhi. 1980, 1st Ed.

SEMESTER IV

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CH5 OR201: RESEARCH OR INDUSTRIAL PROJECT (L-T-P-C: 0-0-20-10)

Program: M. Sc. Chemistry	**Semester:** IV
Course code: CH5 OR201	**Course name:** RESEARCH OR INDUSTRIAL PROJECT

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	20 per week	10	300	Lab	CCE, ESE	100	35

Course Description:

- This is a compulsory course performed in the final semester where the students get a semester-long exposure to research.
- Students who work on research and industrial projects gain valuable training and experience that can help them in their future careers.
- Students can work on real-world research projects proposed by industry or public sector sponsors.
- This course helps to train individuals who contribute to human resources required in the chemical/pharmaceutical industry. The research work may lead to academic research articles as well. They also learn about patents, scientific publications, and literature search tools

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Understand the real-world academic/industrial research problems
CLO2: Apply the knowledge gained during various theoretical and practical courses
CLO3: Design different projects with the knowledge of chemistry to solve existing problems in society
CLO4: Understand data interpretation and data analysis
CLO5: Learn to reboot any experimental problems.

Syllabus: Lab-specific research topics.

CH5 OR202: PROJECT REPORT (L-T-P-C: 2-0-0-2)

Program: M. Sc. Chemistry	**Semester:** IV
Course code: CH5 OR202	**Course name:** PROJECT REPORT

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
2 per week	-	2	30	Lecture	CCE, ESE	100	35

Course Description: In this course, the students learn to summarise their learning experiences.

- They learn the proper ways to write a 'project thesis'.
- This contains a comprehensive overview of a project's objectives, progress, team performance, and milestone accomplishments. It also gives an account of the challenges faced during a project's execution, solutions devised to tackle them, and the lessons learned during the process.
- They also learn about different communication medium like Microsoft word, chemdraw etc.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Understand how to report a practical work into a thesis
CLO2: Learn to publish their research results after the program
CLO3: Learn the art of written scientific communications

Syllabus: Depends on the research performed in respective labs.

CH5 OR203: PROJECT PRESENTATION (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** IV
Course code: CH5 OR203	**Course name:** PROJECT PRESENTATION

Lecture (Hours)	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Passing %**
3 per week	-	3	45	Lecture	CCE, ESE	100	35

Course Description: In this course

- The students mainly learn to communicate their work performed to the audience.
- They learn to use different communication mediums (for example Microsoft PowerPoint) and convince their audience about the research findings.
- This course helps students to increase confidence, presence, and enjoyment of public speaking. The students also learn to use vocal techniques; use tone, range, articulation, power, pace, and pausing to make an impact.
- The students learn the use of body language and gestures to create credibility.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Develop proper communication skills.
CLO2: Defend their accomplished research in front of experts.
CLO3: Gain confidence in facing job interviews.

Syllabus: Depends on the research performed in respective labs.

~:The End:~