VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Syllabus

M.Sc. in Chemistry

(Specialisation: Analytical Chemistry / Organic Chemistry**)**

(Effective from the Academic year 2024-25)

III Semester Syllabus

III SEMESTER

MOLECULAR SYMMETRY AND SPECTROSCOPY			
Course Code	MSC301	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	3	Exam Hours	3

Course Learning Objectives:

- To understand the concepts of symmetry and symmetry operations and their application to CFT, hybridization, MOT and vibrational spectroscopy.
- To learn the theory and applications of microwave, vibration and Raman spectroscopy.
- To understand the principles and applications of UV-Visible and resonance Raman spectroscopy.

Module-1

Molecular symmetry and group theory: Symmetry elements and symmetry operations.

The Point Groups Used with Molecules: Concept of a group, definition of a point group. Classification of molecules into point groups. Subgroups.

Hermann-Maugin symbols for point groups. Multiplication tables (C_{2V}, C_{2h} and C_{3V}). Matrix notation for the symmetry elements. Classess and similarity transformation.

Representation of groups: The Great Orthogonality theorem and its consequences. Character tables (C_s, C_i, C_2, C_{2v}, C_{2h} and C_{3v}). Symmetry and dipole moment.

Module-2

Applications of group theory: Group theory and hybrid orbitals.

Symmetry in Chemical bonding: Group theory to Crystal fieldtheory and Molecular orbital theory (octahedral and tetrahedral complexes).

Symmetry in Vibrational Spectroscopy: Determining the symmetry groups of normal modes for non-linear molecules (H_2O, NH_3, CH_4, trans-N_2F_2) and linear molecules (CO, HCl, HCN and CO_2) (Integration method).

Module-3

Microwave spectroscopy: Rotation spectra of diatomic Molecules - rigid and nonrigid rotator model. Rotational quantum number and the selection rule. Effect of isotopic substitution on rotation spectra. Classification of polyatomic molecules based on moment of inertia. Rotation spectra of polyatomic molecules (OCS CH_3F and BCl_3). Moment of inertia expression for linear tri-atomic molecules. Applications - Principles of determination of Bond length and moment of inertia from rotational spectra. Stark effect in rotation spectra and determination of dipole moments.

Vibration spectroscopy*:* Vibration of diatomic molecules, vibrational energy curves for simple harmonic oscillator. Effects of anharmonic oscillation, expressions for fundamental and overtone frequencies. Vibration - rotation spectra of carbon monoxide. Vibration of polyatomic molecules – The number of degrees of freedom of vibration. Parallel and perpendicular vibrations (CO_2 and H_2O). Combination, difference and hot bands. Fermi resonance. Force constant and its significance. Theory of infrared absorption and theoretical group frequency. Intensity of absorption band and types of absorptions. Applications: Structures of small molecules: XY_2 – linear or bent, XY_3 – planar or pyramidal.

Module-4

Raman spectroscopy: Introduction, Raman and Rayleigh scattering, Stokes and anti-Stokes lines, polarization of Raman lines, depolarization factor, polarizability ellipsoid. Theories of Raman spectra - classical and quantum theory. Rotation-Raman and vibration-Raman spectra. Raman activity of vibrations, rule of mutual exclusion principle. Vibration modes of some simple molecules and their activity.

Resonance Raman Spectroscopy: Resonance Raman Effect and its applications. Non-linear Raman effects: Hyper, stimulated and inverse Raman effects. Coherent Anti-Stokes Raman Scattering and its applications.

Module-5

UV Visible spectroscopy: Quantitative aspects of absorption – Beer's law, Technology associated with absorption measurements. Limitations– real, chemical, instrumental and personal. Theory of molecular absorption. Vibration- rotation fine structure of electronic spectra. Types of absorption bands- n to π^*, π to π^*, n to σ^* and σ to σ^*, C-T and ligand field. Instrumentation.

Applications: Qualitative and quantitative analysis of binary mixtures, measurements of dissociation constants of acids and bases, determination of molecular weight. Woodwards empirical rules for predicting the wavelength of maximum absorption for olefins, conjugated dienes, cyclic trienes and polyenes, α,β-unsaturated aldehydes and ketones, benzene and substituted benzene rings.

References

1. Chemical Applications of Group Theory, 3rd edition, F.A. Cotton, John Wiley and
2. Sons (2006).
3. Molecular Symmetry and Group Theory – Robert L Carter, John Wiley and Sons (2005).
4. Symmetry in Chemistry - H. Jaffe and M. Orchin, John Wiley, New York (1965).
5. Molecular Symmetry – David J. Willock, John Wiley and Sons Ltd., (2009).
6. Group Theory and its Chemical Applications - P.K. Bhattacharya, HimalayaPublications, New Delhi (1998).
7. Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash. 4th edition, Tata McGraw Hill, New Delhi.
8. Fundamentals of molecular spectroscopy, G. M. Barrow, MgGraw Hill, New York (International students Edition), 1974.
9. Theoretical chemistry, S. Glasstone, affiliated East-West Press Pvt. Ltd, New Delhi, 1973.
10. Spectroscopy, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York, Vol. 1 and 2, 1976.
11. Vibration Spectroscopy Theory and Applications, D.N. Satyanarayana, New Age International, New Delhi (2004).
12. Spectroscopy, B.P. Straughan and S. Salker, John Wiley and Sons Inc., New York, Vol.2, 1976.
13. Organic Spectroscopy, William Kemp, English Language Book society, Macmillan, 1987.
14. Instrumental methods of analysis, H. H. Willard, L. L. Merritt and J. A. Dean, 7th Edition, 1988.

Course Outcomes:

CO1	Classify molecules into appropriate point groups, interpret character tables, and use group theory to predict molecular dipole moments and symmetry-based properties.
CO2	Use group theoretical methods to determine orbital hybridization, predict molecular orbital symmetries, and assign symmetry to vibrational modes in simple molecules.
CO3	Analyze rotational and vibrational spectra of diatomic and polyatomic molecules to calculate structural parameters such as bond lengths, force constants, and dipole moments.
CO4	Interpret Raman and resonance Raman spectra, identify Raman active modes, and understand advanced Raman techniques such as CARS and their applications.

CO5	Apply UV-Visible spectroscopic principles and Woodward's rules to identify chromophores, predict absorption maxima, and carry out chemical and structural analysis.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X	X	X		X		X
CO2	X	X	X			X	X
CO3	X	X	X	X	X	X	X
CO4	X	X	X	X	X	X	X
CO5	X	X	X	X	X	X	X

NMR AND MASS SPECTROSCOPY			
Course Code	MSC302	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	3	Exam Hours	3

Course learning objectives are to:

- Understand the basic principles of nuclear magnetic resonance (NMR) spectroscopy, including chemical shift, relaxation processes, and coupling constants.
- Analyze complex NMR spectra using advanced techniques such as FT-NMR, 13C, 19F, and 2D NMR for structural and conformational analysis.
- Understand the principles of mass spectrometry, ionization methods, and fragmentation mechanisms.
- Interpret fragmentation patterns of various functional groups and apply this knowledge in structure elucidation.
- Integrate UV, IR, NMR, and Mass Spectroscopic data to solve real-life problems in structural elucidation, including industrial case studies.

Module-1

NMR Spectroscopy: Magnetic properties of nuclei (magnetic moment, g factor, nuclear spin), effect of external magnetic field on spinning nuclei, Larmor precession frequency, resonance conditions, population of nuclear magnetic energy levels, relaxation processes, relaxation time, line width and other factors affecting line width. Chemical Shift: Standards employed in NMR, factors influencing chemical shift: electronegativity, shielding and deshielding, van der Walls deshielding magnetic anisotropy, H-bonding, diamagnetic and paramagnetic anisotropies, spin-spin coupling, chemical shift values and correlation for protons bonded to carbon and other nuclei, Instrumentation. Chemical shift equivalence and magnetic equivalence, effects of chiral centre, Karplus curve-variation of coupling constants with dihedral angle.

Module-2

Complex NMR Spectra: Simplification of complex spectra-isotopic substitution, increased magnetic field strength, double resonance and lanthanide shift reagents, Nuclear Overhauser Effect (NOE), FT-NMR, Spectroscopy and advantages. 13CNMR Spectroscopy, multiplicity-Proton decoupling-Noise decoupling-Off resonance decoupling-Selective proton decoupling - Chemical shift, application of 13C, 19F, 31P, 11B and 15N. Applications of NMR: Structural diagnosis, conformational analysis, keto-enol tautomerism, H bonding. Solid state NMR and its applications. Multiple resonance spectroscopy: Introduction to 2D-techniques: DEPT, COSY and NOESY

Module-3

Mass Spectrometry: Basic principles, Instrumentation -Mass spectrometer, interpretation of mass spectra, resolution, exact masses of nuclides, molecular ions, meta-stable ions and isotope ions. Different methods of ionization (chemical ionization, electron impact, field ionization, MALDI etc.). Fragmentation processes-representation of fragmentation, basic fragmentation types and rules. Factors influencing fragmentations and reaction pathways. McLafferty rearrangement.

Module-4

Fragmentations (fragmentation of organic compounds with respect to their structure determination) associated with functional groups- alkanes, alkenes, cycloalkanes, aromatic hydrocarbons, halides, alcohols, phenols, ethers, acetals, ketals, aldehydes, ketones, quinines, carboxylic acids, esters, amides, acid chlorides, nitro compounds, amines & nitrogen heterocycles. Fragmentation patterns of glucose, myrcene, nicotine, retro Diels-Alder fragmentation. Application in structure elucidiation and evaluation of heats of sublimation & ionization potential. Nitrogen rule. LC-MS and GC-MS, High resolution mass spectroscopy.

Module-5

Composite problems involving the applications of UV, IR, 1H and 13C-NMR and mass spectroscopic techniques. Structural elucidation of organic and inorganic compounds. Industrial Case studies.

References

1. Organic Spectroscopy-3rd Ed.-W. Kemp (Pagrave Publishers, New York), 1991.
2. Spectrometric Identification of Organic Compounds - Silverstein, Bassler & Monnill (Wiley) 1981.
3. Spectroscopy of Organic Compounds-3rd Ed.-P.S. Kalsi (New Age, New Delhi) 2000.
4. E.A.V. Ebsworth, D.W.H. Ranklin and S. Cradock: Structural Methods in Inorganic Chemistry, Blackwell Scientific, 1991.
5. J. A. Iggo: NMR Spectroscopy in Inorganic Chemistry, Oxford University Press, 1999
6. C. N. R. Rao and J. R. Ferraro: Spectroscopy in Inorganic Chemistry, Vol I & II (Academic) 1970.
7. Spectroscopy, B. P. Straughan and S. Salker, John Wiley and Sons Inc., New Yourk, Vol.2, 1976.
8. Application of Absorption Spectroscopy of Organic Compounds, John R. Dyer, Prentice/Hall of India Private Limited, New Delhi, 1974.
9. Organic Spectroscopy, V. R. Dani, Tata McGraw-Hall Publishing Company Limited, New Delhi. 1995.
10. Interpretation of Carbon-13 NMR Spectra, F.W. Wehrli and T. Wirthin, Heyden, London, 1976.
11. NMR spectroscopy-Powai

Course Outcomes:

CO1	Explain NMR fundamentals such as chemical shifts, spin-spin coupling, and interpret basic 1H NMR spectra.
CO2	Use 13C, 19F NMR, and 2D NMR techniques to analyze complex molecular structures and dynamic processes.
CO3	Describe ionization techniques and predict molecular ion peaks and fragmentation patterns using mass spectrometry.
CO4	Interpret mass spectral fragmentation patterns of organic compounds and correlate them with functional groups.
CO5	Apply combined spectroscopic methods to solve structural problems in academic and industrial contexts.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X		X				X
CO2	X	X	X		X		X
CO3	X	X	X			X	X
CO4	X	X	X		X		X
CO5	X	X	X	X	X	X	X

SOLID STATE AND ELECTROCHEMISTRY			
Course Code	MSC303	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	3	Exam Hours	3

Course Learning Objectives are to:

- Understand crystal structure, Bravais lattices, band theory, and the fundamental principles governing electrical properties of solids.
- Analyze types of crystalline imperfections and their effects on electrical, thermal, and magnetic properties, including behavior of semiconductors and superconductors.
- Understand magnetic behavior in solids including diamagnetism, paramagnetism, ferromagnetism, and novel magnetic materials.
- Understand fundamental electrochemical principles, including ionic conductance, Debye-Hückel theory, and electrical double layers.
- Analyze electrode kinetics and processes such as polarization, overvoltage, and their applications in polarography.

Module-1

Crystal morphology: symmetry elements, crystal systems; Bravais lattices; Crystal planes and directions: Miller indices, interplanar separations. Crystal symmetry, Symmetry elements and symmetry operations. Structure analysis by X-rays: Atomic scattering factor; Laue conditions for diffraction and Bragg's law; Geometrical structure factor, systematic absences; Powder X-ray diffraction. Packing in a crystal: BCC, FCC, HCP structures with examples. Point defects, line defects, plane defects. Free electron theory of metals, Band theory of solids, Effective mass; Direct and Indirect bandgaps: Determination of bandgap; Donors and acceptors, carrier concentration at thermal equilibrium; Calculation of Fermi level; Degenerate and Nondegenerate semiconductors.MO band and zone theories.

Module-2

Imperfections in atomic packing: Types of imperfections, classification of imperfections, point defects, Schottky defects, Frenkel defects, disordered crystals, line defects, dislocation types, plane defects, small-angle and large-angle boundaries, stacking faults, crystal growth and twinning, non-stoichiometry.
Imperfections and physical properties: electrical, optical, magnetic, thermal and mechanical properties. Semiconducors - intrinsic and extrinsic, Hall Effect, Insulators-dielectric, ferroelectric, pyroelectric and Peizoelectric properties, Magnetic properties-Dia, para, ferro, ferri, antiferro and antiferri materials, Defects and dislocations-Vacancies and interstitials, dislocations and grain boundaries colour centers and reactivity, Amorphous materials-glasses and refractories, Superconductivity-Theory and its application.

Module-3

Diamagnetism and Paramagnetism: Langevin's diamagnetism equation, Quantum theory of diamagnetism of mononuclear systems, Quantum theory of paramagnetism, Hund's rule, Paramagnetic susceptibility of conduction electrons, Ferro, Anti and Ferri magnetism: Curie point and the exchange integral, Magnons, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order. Weiss theory of ferromagnetism, Ferromagnetic domains, Bloch walls, Origin of domains, Novel magnetic materials: GMRCMR materials.

Module-4

Electrochemistry of solutions: Factor effecting electrolytic conductance. Debye-Huckel theory - Concept of ionic atmosphere. Debye-Huckel-Onsager equation of conductivity and its validity. Debye- Huckel limiting law (DHL), its modification for appreciable concentrations. A brief survey of

Helmholtz-Perrin, Guoy-Chapman and Stern electrical double layer (no derivation). Transference number: True and apparent transference numbers, Abnormal transference numbers, effect of temperature on transference numbers. Liquid junction potential-determination and minimization.
Energetics of cell reactions: Effect of temperature, pressure and concentration on energetics of cell reactions (calculation of ΔG, ΔH and ΔS).

Module-5

Irreversible electrode process: Introduction, reversible and irreversible electrodes, reversible and irreversible cells. Polarization, over voltage - concentration over voltage, activation over voltage and ohmic over voltage. Experimental determination of over voltage. Equations for concentration over potential, stationary and non-stationary surface. Butler-Volmer equation, Tafel equation. Hydrogen oxygen over voltage. Effect of temperature, current density and *p*H on over voltage. Polarography-Half wave potential, application in qualitative and quantitative analysis.

References

1. D.A McQuarrie and J.D. Simon, Physical Chemistry, a molecular approach, University Science Books.
2. Tareen and Kutty, Solid state chemistry.
3. Lesley Smart & Elaine Moore, SolidState Chemistry, nelson Thornes.
4. A.K. Galway, Chemistry of Solids, Science Paperbacks and Chapman and Hall Ltd., London 91967).
5. A.R. West, basic Solid State Chemsitry, John Wiley & Sons Ltd. (1991).
6. B.S.Skoog and D.M. West, Principles of Instrumental Analysis, Sanndes College, Philadelphia (1980).
7. Atomic structure and chemical Bond, Manas Chanta **Publisher:** McGraw-Hill Inc.,US (1 December 1974) **ISBN-10:** 0070965110
8. Concise Inorganic chemistry, J.D.Lee **Publisher:** Wiley; 5th edition edition (18 December 1998) **ISBN-10:** 0632052937
9. Inorganic Chemistry, G. Wwfsberg Unit IV **Publisher:** Pearson; 4 edition (31 May 2012) **ISBN-10:** 0273742752
10. Introduction to solids – L.V. Azaroff **Publisher:** McGraw Hill Education; New edition edition (14 June 2001) **ISBN-10:** 0070992193
11. Introduction to solid state Physics – C. Kittel **Publisher:** John Wiley & Sons Inc (23 July 1996) **ISBN-10:** 0471142867
12. Elements of solids state physics, J.P. Srivastava **Publisher:** Prentice Hall India Learning Private Limited; 4th Revised edition edition (17 December 2014) **ISBN- 10:** 8120350669
13. Superconductivity and Superconducting Materials – A V Narlikar and S N Ekbote (South Asian Pub., 1983).
14. Physics of high Tc superconductors – J C Phillips (Academic Press, 1989)
15. Introduction to superconductivity – A C Rose-Innes and E H Rhoderick (Pergamon Press, 1978)
16. D. I. Antropov, Theoretical Electrochemistry, Mir Publishers, 1972.
17. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol.1 and 2, Plenum Press, 1998.
18. Industrial Electrochemistry, 2nd ed, Pletcher, Derek/Walsh, Frank C., London: Chapman and Hall, 1990
Electrochemistry for Chemists, 2nd ed, Sawyer, Donald T./Sobkowiak, Andrej/Roberts, Julian L., New York: John Wiley, 1995
19. Introduction to Electrochemistry by S. Glasstone, Affiliated East-West Press, New Delhi,
20. Electrochemistry –Principles and Applications by E.G. Potter, Cleaver-Hume press Ltd, London.
21. Modern Electrochemistry Vol. I and II by J.O.M. Bockris and A.K.N. Reddy, Pentium Press, New

York (1970).

Course Outcomes:

CO1	Explain crystal structure, lattice types, band theory, and electrical properties of metals and semiconductors.
CO2	Analyze the role of imperfections in determining the physical properties of materials such as semiconductors and superconductors.
CO3	Describe the magnetic behavior of solids using classical and quantum theories and explain the significance of magnetic ordering.
CO4	Apply electrochemical theories to explain ionic conductance, double layer formation, and transport numbers.
CO5	Evaluate irreversible electrode processes, interpret polarization data, and apply principles of polarography in chemical analysis.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X		X				X
CO2	X	X	X				X
CO3	X		X			X	X
CO4	X		X				X
CO5	X	X	X	X		X	X

NANOSCIENCE AND APPLICATIONS			
Course Code	MSC304	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning Objectives are to:

- Understand the fundamental concepts, classification, and surface phenomena unique to the nanoscale regime.
- Learn various top-down and bottom-up synthetic strategies for nanomaterials including green and biological methods.
- Acquire knowledge of instrumentation and principles behind key nanomaterial characterization techniques.
- Analyze the unique properties and diverse applications of nanomaterials in various technological domains.
- Explore biomedical applications, nanotoxicology, ethical implications, and emerging trends in nanoscience.

Module-1

Fundamentals of Nanoscience

Introduction & Scope: History and evolution of nanoscience and nanotechnology; interdisciplinary nature.

Size & Scale Concepts: Nanoscale dimensions, units, and visualization; nanometers vs bulk scale.

Classification of Nanostructures: Zero-dimensional, one-dimensional, two-dimensional, and three-dimensional nanostructures.

Quantum Phenomena: Quantum confinement effect in electronic, optical, and magnetic properties.

Surface Effects: High surface-to-volume ratio, surface energy, and reactivity.

Self-assembly Principles: Spontaneous organization at nanoscale.

Module-2

Top-down **Synthesis of Nanomaterials**

Approaches: Mechanical attrition/ball milling, lithography, laser ablation.

Bottom-up Approaches: CVD, PVD, molecular beam epitaxy.

Chemical Routes: Sol–gel process, hydrothermal and solvothermal methods, microemulsion, co-precipitation.

Green & Biological Routes: Plant-mediated synthesis, microbial-assisted methods. Template-Assisted Synthesis: Use of porous templates and surfactants.

Module-3

Characterization of Nanomaterials: Principle, Instrumentation and applications of following methods.

Structural Characterization: XRD, SAXS.

Morphological Analysis: SEM, TEM, HRTEM, AFM, STM.

Spectroscopic Techniques: UV–Vis, FTIR, Raman, XPS.

Surface Area & Porosity: BET, BJH methods.
Thermal Analysis: TGA/DSC/DTA.

Module-4

Properties and Applications of Nanomaterials

Optical Properties: SPR, quantum dot fluorescence, photonic crystals.
Electrical/Electronic Properties: Band gap tuning, conductivity enhancement, nanotransistors.
Mechanical Properties: Strengthening mechanisms, nanocomposites.
Magnetic Properties: Superparamagnetism, magnetic nanoparticles.
Catalytic Properties: Enhanced catalytic activity due to surface area.
Applications: Catalysis, sensors, energy storage and conversion, environment, smart materials.

Module-5

Nanoscience in Biology and Medicine

Biomedical Applications: Targeted drug delivery, nanodiagnostics, nano-biomaterials.
Therapeutics: Cancer therapy, magnetic hyperthermia.
Nanotoxicology: Mechanisms of toxicity, biocompatibility issues.
Ethical & Societal Issues: Responsible use, regulations, environmental concerns.
Emerging Frontiers: Nanorobotics, nanoelectronics in healthcare.

References

1. C.N.R. Rao, A. Muller, A.K. Cheetham, "The Chemistry of Nanomaterials: Synthesis, Properties and Applications," Wiley-VCH, 2005.
2. Charles P. Poole Jr., Frank J. Owens, "Introduction to Nanotechnology," Wiley-Interscience, 2003.
3. G. Cao, Y. Wang, "Nanostructures and Nanomaterials: Synthesis, Properties and Applications," World Scientific, 2011.
4. T. Pradeep, "Nano: The Essentials – Understanding Nanoscience and Nanotechnology," McGraw-Hill Education, 2007.
5. Dieter Vollath, "Nanomaterials: An Introduction to Synthesis, Properties and Applications," Wiley-VCH, 2013.

Course Outcomes:

CO1	Explain nanoscale concepts, surface effects, quantum phenomena, and classification of nanostructures.
CO2	Evaluate and compare various physical, chemical, and biological synthesis methods for nanomaterials.
CO3	Select and apply appropriate techniques for structural, morphological, and spectroscopic characterization of nanomaterials.
CO4	Relate nanoscale properties (optical, electrical, mechanical, etc.) to their real-world applications in materials and energy.
CO5	Analyze nanoscience applications in biology and medicine, including nanotoxicology and ethical/societal concerns.

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	X		X			X	X
CO2	X	X	X			X	X
CO3	X	X	X			X	X
CO4	X	X	X		X	X	X
CO5	X	X	X	X	X	X	X

ANALYTICAL CHEMISTRY PRACTICAL - I			
Course Code	MSC315A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1:6:0	SEE Marks	50
Total Hours of Pedagogy	72	Total Marks	100
Credits	4	Exam Hours	3

Course Learning Objectives are to:

- **Understand the fundamental principles** behind various classical and instrumental analytical techniques such as titrimetry, potentiometry, spectrophotometry, and polarography.
- **Develop practical laboratory skills** for the quantitative determination of elements and compounds in diverse real-world samples such as pharmaceuticals, food products, and alloys.
- **Learn and apply complexometric titrations** using EDTA and other chelating agents with appropriate masking/demasking techniques.
- **Utilize redox and acid-base titrations** in the analysis of both organic and inorganic compounds.
- **Gain experience in instrumental methods** such as potentiometry, polarography, and spectrophotometry for accurate and sensitive analysis.
- **Interpret experimental results**, identify sources of error, and apply statistical tools where applicable.
- **Foster scientific thinking and problem-solving skills** in analytical method selection and data analysis.

1. Determination of calcium in limestone by redox, acid-base and complexation titrations.
2. Determination of vitamin C in orange juice by titration with cerium (IV) and with 2,6-dichlorophenol indophenols.
3. Determination of aluminium and magnesium in antacids by EDTA titration.
4. Analysis of a copper-nickel alloy sample for copper and nickel by EDTA titration using masking and selective demasking reactions.
5. Determination of saccharin in tablets by precipitation titration.
6. Determination of ascorbic acid in goose berry/bitter gourd by titrimetry and spectrophotometry using *N*-bromosuccinimide (NBS).
7. Analysis of a mixture of iron (II) and iron (III) by EDTA titration using *p*H control.
8. Determination of sulpha drugs by potentiometry using $NaNO_2$ and iodometric assay of penicillin.
9. Polarographic determination of copper and zinc in brass.
10. Determination of manganese in steel by extraction-free spectrophotometry and molybdenum in steel by extractive spectrophotometry.
11. Determination of iron in mustard seeds and phosphorous in peas by spectrophotometry.
12. Synthesis of Fe_2O_3/Mn_3O_4 nanoparticles by Co-precipitation method
13. Copper nanoparticles (reduction) $CuSO_4$ reduction with ascorbic acid; UV-Vis, oxidation stability test.

References

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall,

Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and
M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Practical Clinical biochemistry methods and interpretations, R. Chawla, J.P. Bothers Medical Publishers (P) Ltd., 1995.
7. Laboratory manual in biochemistry, J. Jayaraman, New Age International Publishers, New Delhi, 1981.
8. Practical Clinical Biochemistry by Harold Varley and Arnold. Heinmann, 4th edition.

Course Outcomes:

CO1	Perform accurate volumetric analyses using redox, acid-base, and complexometric titrations.
CO2	Analyze pharmaceutical and food samples for active ingredients using titrimetric and instrumental methods.
CO3	Apply EDTA titration techniques with masking and demasking for multi-metal systems.
CO4	Use potentiometry for endpoint detection in complex mixtures.
CO5	Operate polarographic and spectrophotometric instruments for trace-level determinations.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X	X	X				X
CO2	X	X	X				X
CO3	X	X	X				X
CO4	X	X	X				X
CO5	X	X	X				X

ANALYTICAL CHEMISTRY PRACTICAL - II			
Course Code	MSC315B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1:6:0	SEE Marks	50
Total Hours of Pedagogy	72	Total Marks	100
Credits	4	Exam Hours	3

Course Learning Objectives are to:

- **Understand and apply analytical techniques** for the analysis of environmental, biological, and industrial samples.
- **Develop hands-on skills** in instrumental methods such as **potentiometry, conductometry, spectrophotometry, turbidimetry, and coulometry**.
- **Carry out complexometric, redox, and acid-base titrations** in diverse chemical matrices (e.g., soil, water, biological fluids).
- **Analyze pollutants and key nutrients** in environmental samples using classical and modern methods.
- **Correlate experimental data with theoretical chemistry principles**, especially related to chemical equilibria and electrochemical methods.
- **Handle sample preparation and separation techniques**, such as ion exchange, to isolate and quantify specific analytes.
- **Interpret results, maintain accurate records**, and report data using scientific formats.

1. Analysis of waste waters for DO, BOD and COD by titrimetry.
2. Nitrate & nitrite estimation in wastewater/soil extracts by spectrophotometric (Griess reagent) or ion chromatography.
3. Analysis of a ground water sample for sulphate by titrimetry (EDTA) and turbidimetry.
4. Analysis of brackish water for chloride content by a**)** spectrophotometry (mercuric thiocyanate method), b) conductometry (silver nitrate) and c**)** potentiometry (silver nitrate).
5. Analysis of waste water for: a) Phosphate by molybdenum blue method
   b) Ammonia-nitrogen by Nessler's method
6. Ascorbic acid determination in natural orange juice by coulometry.
7. Analysis of a soil sample for: a) Calcium carbonate and organic carbon by titrimetry.
8. Analysis of a soil sample for:
   a) Available phosphorus by spectrophotometry.
   b) Sodium/Potassium by spectrophotometry.
9. Analysis of urine for:
   a) Urea and uric acid by titrimetry and spectrophotometry.
   b) Sulphate by precipitation titration after ion-exchange separation.
   c) Sugar by Benedict's reagent.
10. Analysis of blood for:
    a) Cholesterol by spectrophotometry
    b) Bicarbonate by acid-base titration.
11. Titrimetric assay for an acidic/basic drug (aspirin, paracetamol)
12. Estimation of concentration Tannins & Lignin (natural organic matter and industrial tannins)

References

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Practical Clinical biochemistry methods and interpretations, R. Chawla, J.P. Bothers Medical Publishers (P) Ltd., 1995.
7. Laboratory manual in biochemistry, J. Jayaraman, New Age International Publishers, New Delhi, 1981.
8. Practical Clinical Biochemistry by Harold Varley and Arnold. Heinmann, 4th edition.

Course Outcomes:

CO1	Quantify chemical parameters in **wastewater** and **groundwater** using titrimetric and instrumental methods.
CO2	Apply **potentiometric and photometric techniques** in the analysis of metal ions and complex ions.
CO3	Evaluate **nutrient and pollutant levels in soil and agricultural samples** using classical and instrumental methods.
CO4	Analyze **biological fluids** (urine and blood) for health-related compounds using wet chemistry and instrumentation.
CO5	Perform advanced **electroanalytical techniques** such as **coulometry** and **conductometry** in real samples.
CO6	Demonstrate **data interpretation and reporting** skills, ensuring accuracy and adherence to safety practices.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X	X	X				X
CO2	X	X	X				X
CO3	X	X	X			X	X
CO4	X	X	X				X
CO5	X	X	X				X
	X	X	X	X	X		X

ORGANIC CHEMISTRY PRACTICAL - I			
Course Code	MSC316A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1:6:0	SEE Marks	50
Total Hours of Pedagogy	72	Total Marks	100
Credits	4	Exam Hours	3

Course Learning Objectives are:

- To develop proficiency in classical organic separation and purification techniques.
- To understand the principles and applications of chromatography methods.
- To gain hands-on experience in isolating natural organic compounds from various sources.
- To enhance analytical and observational skills through practical experimentation.
- To promote accuracy and safety awareness in the laboratory environment.

Isolation of natural products

1. Fractional crystallization: separation of mixture of naphthalene and biphenyl
2. Fractional distillation: Separation of mixture of benzene and toluene.
3. Thin layer chromatography: Separation of plant pigments
4. Column chromatography: Separation of mixture of o- and p-nitro anilines
5. Paper chromatography: Separation of amino acids
6. Isolation of piperine from pepper
7. Isolation of caffeine from tea
8. Isolation of azeleic acid from castor oil
9. Isolation of Lycopene from tomato
10. Isolation of carotene from carrot.

References

1. Manual of Organic Chemistry - Dey and Seetharaman.
2. A Text Book of Practical Organic Chemistry – A.I. Vogel, Vol.III
3. Practical Organic Chemistry - Mann & Saunders
4. Modern Experimental Organic Chemistry by John H. Miller and E.F. Neugil, p 289.
5. An Introduction to Practical Organic Chemistry - Robert, Wingrove etc
6. Natural Products Chemistry by Raphel Ikhan

Course Outcomes:

CO1	Perform fractional crystallization and distillation for separation of organic mixtures.
CO2	Apply chromatographic techniques (TLC, column, paper chromatography) to separate and analyze compounds.
CO3	Isolate and purify natural products such as piperine, caffeine, azelaic acid, lycopene, and carotene.
CO4	Interpret chromatograms and assess the purity of separated compounds.
CO5	Demonstrate safe laboratory practices and maintain accurate records during organic separations.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X	X	X				X
CO2	X	X	X				X
CO3	X	X	X				X

	CO4	X	X	X		X		X	
					X	X		X	

ORGANIC CHEMISTRY PRACTICAL - II			
Course Code	MSC316B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1:6:0	SEE Marks	50
Total Hours of Pedagogy	72	Total Marks	100
Credits	4	Exam Hours	3

Course Learning Objectives are:

- To understand and apply classical quantitative estimation methods for functional groups in organic compounds.
- To develop skills in performing chemical estimations such as iodine value, saponification value, and functional group quantification.
- To enhance precision in titrimetric and colorimetric analysis related to organic substances.
- To interpret experimental data to calculate concentrations and values relevant to oil, fats, and organic molecules.
- To reinforce laboratory safety, accuracy, and good documentation practices during quantitative analyses.

Estimations

1. Determination of iodine value of oil and fats by chloramine-T
2. Saponification value of an oil or fats
3. Estimation of hydroxyl groups
4. Estimation of vicinal hydroxyl groups
5. Estimation of ketones by haloform method
6. Estimation of sugars by Bertrand's method
7. Estimation of nitro groups
8. Estimation of amino acids
9. Estimation of ketones by oxime method

References

1. Manual of Organic Chemistry - Dey and Seetharaman.
2. A Text Book of Practical Organic Chemistry – A.I. Vogel, Vol.III
3. Practical Organic Chemistry - Mann & Saunders
4. Modern Experimental Organic Chemistry by John H. Miller and E.F. Neugil, p 289.
3. An Introduction to Practical Organic Chemistry - Robert, Wingrove etc
2. Natural Products Chemistry by Raphel Ikhan

Course Outcomes:

CO1	Perform titrimetric estimations of iodine and saponification values in oils and fats accurately.
CO2	Quantitatively estimate functional groups such as hydroxyl, vicinal hydroxyl, ketones, nitro, and amino groups in organic compounds.
CO3	Apply classical chemical methods such as the haloform test and Bertrand's method for sugar estimation.
CO4	Analyze and interpret experimental data to determine concentrations of specific organic components.

CO5	Maintain laboratory safety, precision, and proper documentation during quantitative organic analysis.

Mapping of COs and POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	X	X	X				X
CO2	X	X	X				X
CO3	X	X	X				X
CO4	X	X	X		X		X
				X	X		X