DEPARTMENT OF CHEMISTRY
GURU JAMBHESHWAR UNIVERSITY OF SCIENCE AND TECHNOLOGY, HISAR

Structure and Syllabus of M.Sc. Chemistry programme (w.e.f. July, 2022)

Name of the Programme: **M.Sc. Chemistry**
Choice Based Credit System and Learning Outcome based Curriculum Framework
Duration of the Programme: **Two Years (Four Semesters)**
Total Credits for the Programme: **102 Credits**

Sr. No	Course	Credits								Total Credits	Total Marks
		First Semester		Second Semester		Third Semester		Fourth Semester			
		Theory	Practical	Theory	Practical	Theory	Practical	Theory	Practical		
1.	Core	12	12	16	12	4	-	6	-	62	1550
2.	Discipline Elective (DE)	-	-	-	-	8	8	8	6	30	750
3.	Foundation Elective (FE)	2	-	-	-	2	-	2		06	150
4.	Open Elective (OE)/MOOCs	-	-	-	-	4			-	04	100
Grand Total		**26**		**28**		**26**		**22**		**102**	**2550**

FIRST SEMESTER								
Sr. No	**Course Code**	**Course**	**Nomenclature**	**Teaching Hours/ week**	**Credits**	**Marks**		
						Internal	**External**	**Total**
1.	MCL-511	Core	Bonding and Properties of Inorganic Compounds	4	4	30	70	100
2.	MCL-512	Core	Structure and Mechanism in Organic Chemistry-1	4	4	30	70	100
3.	MCL-513	Core	Thermodynamics and Electrochemistry	4	4	30	70	100
4.	MCL-514 (a) or MCL-514 (b)	FE	Mathematics for Chemists* or Biology for Chemists**	2	2	15	35	50
5.	MCP-515	Core	Inorganic Chemistry Practical - I	8	4	30	70	100
6.	MCP-516	Core	Organic Chemistry Practical - I	8	4	30	70	100
7.	MCP-517	Core	Physical Chemistry Practical - I	8	4	30	70	100
Total					**26**			**650**

* The students having Biology at B.Sc. level will study Mathematics for Chemists.
**The students having Mathematics at B.Sc. level will study Biology for Chemists.

SECOND SEMESTER								
Sr. No	**Course Code**	**Course**	**Nomenclature**	**Teaching Hours/ week**	**Credits**	**Marks**		
						Internal	**External**	**Total**
1.	MCL-521	Core	Transition Metal Chemistry	4	4	30	70	100
2.	MCL-522	Core	Structure and Mechanism in Organic Chemistry-II	4	4	30	70	100
3.	MCL-523	Core	Quantum Chemistry and Chemical Kinetics	4	4	30	70	100
4.	MCL-524	Core	Symmetry and Spectroscopy	4	4	30	70	100
5.	MCP-525	Core	Inorganic Chemistry Practical - II	8	4	30	70	100
6.	MCP-526	Core	Organic Chemistry Practical - II	8	4	30	70	100
7.	MCP-527	Core	Physical Chemistry Practical - II	8	4	30	70	100
Total					**28**			**700**

THIRD SEMESTER								
Sr. No	**Course Code**	**Course**	**Nomenclature**	**Teaching Hours/ week**	**Credits**	**Marks**		
						Internal	**External**	**Total**
1.	MCL-531	Core	Applications of Spectroscopy	4	4	30	70	100
2.	MCL-532 (IC) **OR** MCL-532 (OC) **OR** MCL-532 (PC)	DE	Organometallic Chemistry **OR** Heterocyclic and Photochemistry **OR** Surface Chemistry and Non-Equilibrium Thermodynamics	4	4	30	70	100
3.	MCL-533 (IC) **OR** MCL-533 (OC) **OR** MCL-533 (PC)	DE	Chemical Analysis and Inorganic Spectroscopy **OR** Bioorganic and Natural Products Chemistry **OR** Quantum Chemistry and Group Theory	4	4	30	70	100
4.	MCP-534 (IC) **OR** MCP-534 (OC) **OR** MCP-534 (PC)	DE	Inorganic Chemistry Practical-III **OR** Organic Chemistry Practical-III **OR** Physical Chemistry Practical-III	8	4	30	70	100
5.	MCP-535 (IC) **OR** MCP-535 (OC) **OR** MCP-535 (PC)	DE	Inorganic Chemistry Practical-IV **OR** Organic Chemistry Practical-IV **OR** Physical Chemistry Practical-IV	8	4	30	70	100
6.	----	OE	To be opted from other Departments **OR** Massive Open Online Courses (MOOCs)	4	4	30	70	100
7.	MCS-536	FE	Seminar	4	2		50	50
			Total		**26**			**650**

Open Elective for the students of other Departments								
1.	MCL-537 (OE)	OE	Introduction to Spectroscopy	4	4	30	70	100

FOURTH SEMESTER								
Sr. No	**Course Code**	**Course**	**Nomenclature**	**Teaching Hours/ week**	**Credits**	**Marks**		
						Internal	**External**	**Total**
1.	MCL-541	Core	Instrumental Methods of Analysis	4	4	30	70	100
2.	MCL-542	Core	General Polymer Chemistry	2	2	15	35	50
3.	MCL-543	FE	Chemistry and Society	2	2	15	35	50
4.	MCL-544 (IC) **OR** MCL-544 (OC) **OR** MCL-544 (PC)	DE	Photo and Bioinorganic Chemistry **OR** Organic Synthesis **OR** Solid State and Biophysical Chemistry	4	4	30	70	100
5.	MCL-545 (IC) **OR** MCL-545 (OC) **OR** MCL-545 (PC)	DE	Chemistry of Materials **OR** Medicinal Chemistry **OR** Physical Polymer Chemistry	4	4	30	70	100
6.	MRP-546 (IC) **OR** MRP-546 (OC) **OR** MRP-546 (PC)	DE	Inorganic Chemistry Project **OR** Organic Chemistry Project **OR** Physical Chemistry Project	12	6	45	105	150
			Total		**22**			**550**

M.Sc. Chemistry

Programme Outcomes

PO1 Sound knowledge of fundamentals of Chemical Sciences.

PO2 Understanding of multidisciplinary areas of physical sciences and their applications.

PO3 Analytical skills through knowledge of various techniques for qualitative and quantitative analysis.

PO4 Better approach using Green Chemistry methodologies in Chemical Sciences and industrial processes.

PO5 Capability for design, synthesis, isolation, separation, purification and characterization of natural and synthetic compounds.

PO6 Ability to gain chemical information from various sources through self-learning.

PO7 Solving scientific and socio-economic problems.

PO8 Understanding of hazards, safety data of materials for safe-guard of living beings and environment.

PO9 Capability of drawing logical conclusion based on theoretical knowledge and practical observations.

PO10 Effective communication, critical thinking, teamwork and ethics as a life-long learner.

M.Sc. Chemistry

FIRST SEMESTER

M.Sc. Chemistry, First Semester
Bonding and Properties of Inorganic Compounds

Course code: MCL-511
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with bonding and properties of Lanthanides, Actinides and Non-Transition elements.

Unit-I **15 Hrs**

Theories of Bonding in Co-ordination Complexes

Valence bond theory, electro neutrality principle and limitations, crystal field theory splitting of d-orbitals in cubic, octahedral, tetragonal, tetrahedral and square planar ligand environments. Structural consequences of splitting of d-orbitals, Jahn Teller theorem, trends in ionic radii, lattice energy and heat of ligation. Structure of spinels. MOT with σ and π bonding.

Unit-II **15 Hrs**

Chemistry of Lanthanides and Actinides

Extraction and applications, colour and spectra, magnetic properties, binary and ternary compounds, oxo salts, cyclopentadienyl compounds, Low oxidation state compounds, Lanthanide contraction, Use of lanthanide compounds as shift reagents.

General properties, oxidation states, dioxoions, chemistry of actinium, thorium, protactinium, uranium, uranyl and cyclopentadienyl compounds, transuranic elements, later actinide elements.

Unit-III **15 Hrs**

Chemistry of Non-Transition Elements

General discussion on the properties of the non-transition elements, special features of individual elements, synthesis, properties and structure of their halides and oxides, polymorphism of carbon, phosphorus and sulphur, Synthesis, properties and structure of boranes, carboranes, borazines, silicates, phosphazenes, sulphur-nitrogen compounds, oxy acids of nitrogen, phosphorus, sulphur and halogens, interhalogens, pseudohalides and noble gas compounds.

Unit-IV **15 Hrs**

Non-aqueous Solvents

Solvent system definition, reactions in non-aqueous media with respect to sulphuric acid, ammonia, sulphur trioxide, bromine trifluoride, dinitrogen tetraoxide, hydrogen fluoride, thionyl chloride and phosphoryl chloride. Mechanism of coordination reactions in non-aqueous media.

Books Suggested:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huheey and Harper Collins.
3. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon.
4. Magnetochemistry, R.L. Carlin, Springer Verlog.
5. Inorganic Chemistry, G. Wulf'sburg.
6. Introduction to ligand fields, B.N. Figgis, Wiley Eastern.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Describe the theories of bonding in coordination compounds.
CO2 Explain the Chemistry of Lanthanides.
CO3 Explain the Chemistry of Actinides.
CO4 Discuss the synthesis, structure and properties of non-transition elements.
CO5 Describe the mechanism of coordination reactions in non-aqueous solvents.

Mapping of CO's with PO's

MCL-511

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	W	S	W	S	W	W	S	M
CO2	S	S	S	M	S	S	S	M	S	S
CO3	S	S	S	M	S	S	S	M	S	S
CO4	S	S	S	S	S	S	S	M	S	S
CO5	S	M	S	S	S	S	S	M	S	S

S-Strong, M-Medium, W-Weak

M.Sc. Chemistry, First Semester
Structure and Mechanism in Organic Chemistry -I

Course code: MCL-512
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of structure and reaction mechanism in organic chemistry.

Unit-I **15 Hrs**

Nature of Bonding in Organic Molecules

Delocalized chemical bonding, conjugation, cross conjugation, resonance, hyperconjugation, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Hückel's rule, annulenes, anti-aromaticity, homo-aromaticity. Bonding weaker than covalent – EDA Complexes, addition compounds, crown ether complexes and cryptates, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

Unit -II **15 Hrs**

Stereochemistry

Optical activity and chirality, methods of determining configuration, molecules with more than one stereogenic center, asymmetric synthesis (basic principle, auxiliary, substrate, reagent and catalyst controlled). Methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes); Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Unit -III **15 Hrs**

Reaction Mechanism: Structure and Reactivity

Types of mechanism, types of reaction, thermodynamic and kinetic requirements for reaction, Potential energy diagrams, kinetic and thermodynamic control, the Hammond postulate, Curtin-Hammett principle, methods of determining mechanisms, Generation, structure, stability and reactivity of carbocations, carbanions free radicals, carbenes and nitrenes. Effect of structure on reactivity – resonance and field effects, steric effect. Quantitative treatments of the effect of structure on reactivity - Hammett equation and linear free energy relationship.

Unit -IV **15 Hrs**

Aliphatic Nucleophilic Substitution

The S_N2, S_N1 and SET Mechanisms; The neighbouring group mechanism, neighbouring group participation by σ and π bonds; nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements; The S_Ni mechanism. Nucleophilic substitution at an allylic carbon: allylic rearrangement, aliphatic trigonal carbon: the tetrahedral mechanism. Reactivity - effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase-transfer catalysis and regioselectivity.

Elimination Reactions

The E2, E1 and E1cB mechanisms. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium.

Books Suggested:

1. March's Advanced Organic Chemistry-Reactions, Mechanisms and Structure, Michael B. Smith and Jerry March, Wiley-Interscience.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Springer.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, CBC Publisher & Distributors.
5. Organic Chemistry, R.T. Morrison, R.N. Boyd and S. K. Bhattacharjee, Pearson.
6. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh revised by S.P. Singh and Om Prakash, Trinity.
7. Organic Chemistry, P.Y. Bruice, Pearson.
8. Organic Chemistry, J. Clayden, N. Geeves and S. Warren, Oxford University Press.
9. Organic Chemistry, T.W.G. Solomon, W.B. Fryhl and S.A. Snyder, Wiley.
10. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
11. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.
12. Stereochemistry of Organic Compounds, E.L. Eliel and S.H. Wilen, Wiley Interscience.
13. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Harcourt India Pvt. Ltd.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Describe the aromaticity, anti-aromaticity, homo-aromaticity and non-covalent interactions in organic compounds.
CO2 Explain optical activity, chirality, methods of determining configuration and asymmetric synthesis.
CO3 Describe methods of resolution, conformational analysis, stereospecific and stereoselective synthesis.
CO4 Describe different methods for determining reaction mechanism.
CO5 Analyze the structure, stability and reactivity of reaction intermediates
CO6 Explain mechanistic details of various nucleophilic substitutions, elimination reactions.

Mapping of CO's with PO's
MCL-512

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	W	M	S	S	W	S	S
CO2	S	S	M	W	M	S	S	W	S	S
CO3	S	S	S	W	S	S	S	W	S	S
CO4	S	M	S	M	S	S	S	M	S	S
CO5	S	M	S	M	S	S	S	M	S	S
CO6	S	M	S	M	S	S	S	M	S	S

S= Strong, M= medium, W= weak

M.Sc. Chemistry, First Semester
Thermodynamics and Electrochemistry

Course code: MCL-513
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of thermodynamics and electrochemistry.

Unit-I **15 Hrs**

Classical Thermodynamics

Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties- partial molar free energy, partial molar volume and partial molar heat content and their significance, determination of these quantities. Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient, Debye-Hückel theory for activity coefficient of electrolytic solutions, determination of activity and activity coefficients, ionic strength.

Application of phase rule to three component systems; second order phase transitions.

Unit-II **15 Hrs**

Statistical Thermodynamics

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers).

Partition functions– translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.

Heat capacity, behavior of solids – chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose–Einstein statistics- distribution law and application to helium.

Unit-III **15 Hrs**

Electrochemistry-I

Electrochemistry of solutions: Debye-Hückel–Onsager treatment and its extension, ion-ion interactions, electrode/electrolyte interface, potential difference across electrified interfaces, nonpolarizable interface and equilibrium, concept of surface excess; thermodynamics of electrified interfaces- interfacial tension, electro-capillarity curves, thermodynamic treatment of polarizable interfaces, Lippmann equation, determination of charge density on electrode, capacitance of interface and surface excess.

Structure of electrified interfaces: Helmholtz-Perin, Guoy-Chapman, Stern and Devanathan models.

Unit-IV **15 Hrs**

Electrochemistry-II

Semiconductor-electrolyte interface– theory of double layer at semiconductor, Effect of light on semiconductor solution interface.

Electron transfer under interfacial electric field: exchange current density, over potentials, derivation of Butler-Volmer equation, Tafel plot.
Polarography theory, Ilkovic equation, half wave potential and its significance.

Fuel Cells and Batteries: Energy conversion, theoretical consideration of fuel cells, maximum intrinsic efficiency, Hydrogen–Oxygen cell and Hydrocarbon –Air cells.

Battery characteristics specification, components, battery systems, Lead storage battery, Dry cell, Silver-Zinc cell, Ni-Cd and Li battery.

Books Suggested:

1. Physical Chemistry, P.W. Atkins, Oxford University Press.
2. Physical Chemistry, G.W. Castellan, Narosa Publishers.
3. Introduction to Electrochemistry, S. Glasstone.
4. Modern Electrochemistry Vol.1 and Vol. II, J.O.M. Bockris and A.K.N. Reddy, Plenum.
5. Thermodynamics for Chemists, S. Glasstone, Affiliated East-West Press.
6. Chemical Thermodynamics, I.M. Klotz and R.M. Rosenberg, Benzamin.
7. Introduction to Chemical Thermodynamics, R. P. Rastogi and R.R. Mishra, Vikas Publication.

Course outcomes:

At the end of the course, the students would be able to:

CO1	Understand the basic laws of thermodynamics and the related properties
CO2	Explain Debye-Huckel Theory for determination of activity & activity coefficients of electrolytic solution
CO3	Apply Statistical thermodynamics for energy distribution.
CO4	Elucidate the electrified interfaces and surface excess in electrochemical systems
CO5	Describe electrodic reactions and their rates.
CO6	Design and Set-up the fuel cells and batteries.

Mapping of CO's with PO's
MCL-513

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	S	S	S	M
CO2	S	M	M	W	S	S	S	W	S	W
CO3	S	M	W	W	W	S	S	M	S	S
CO4	S	M	M	M	M	S	M	S	S	M
CO5	S	M	S	S	M	S	S	S	S	M
CO6	S	S	S	S	S	S	S	S	S	S

S = Strong; M = Medium; W = Weak

M.Sc. Chemistry, First Semester
Mathematics for Chemists

Course code: MCL-514(a)
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time: 2 Hrs **Total Marks: 50**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of three to four short answer type questions). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of mathematics to be applied in chemistry.

Unit-I **8 Hrs**

Vectors and Matrix Algebra

Vectors

Vectors: dot, cross and triple products of vectors etc. examples from angular momentum. The gradient, divergence and curl.

Vector calculus: Gauss Divergence theorem, Surface integral, Volume integral.

Matrix Algebra

Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric, skew-symmetric, Hermitian, skew-Hermitian, unit, diagonal, unitary etc.) and their properties. Solution of Homogeneous, non-homogeneous linear equations and conditions for the solution.

Unit-II **7 Hrs**

Matrix eigenvalues and eigenvectors, diagonalization, determinants (examples from Hückel theory).

Permutation, Probability and Curve Fitting

Permutations and combinations, probability and probability theorems, probability curves, average, root mean square and most probable errors, examples from the kinetic theory of gases etc., curve fitting (including least squares fit etc.) with a general polynomial fit.

Unit-III **7 Hrs**

Differential Calculus

Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc.), Exact and inexact differentials with their applications to thermodynamic properties.

Unit-IV **8 Hrs**

Integral Calculus and Elementary Differential Equations

Integral calculus, basic rules for integration, integration by parts, partial fraction and substitution. partial differentiation, co-ordinate transformations.

Solutions of differential equations of first order by separation of variables Homogeneous, Linear and Exact equations. Applications to chemical kinetics, quantum chemistry etc. Solutions of differential equations by the power series method. Fourier series. The second order differential equations and their solutions.

Partial differential equation: introduction, formation of partial differential equation, solution of the partial differential equation, linear equation of the first order (Lagrange's equation), non-linear equation of the first order.

Books Suggested:

1. The Chemistry Mathematics Book, E. Stener, Oxford University Press.
2. Mathematics for Chemistry, Doggett and Sucliffe, Longman.
3. Mathematical Preparation for Physical Chemistry, F. Daniels, McGraw Hill.
4. Chemical Mathematics, D.M. Hirst, Longman.
5. Applied Mathematics for Physical Chemistry, J.R. Barrante, Prentice Hall.
6. Basic Mathematics for Chemists, Tebbutt, Wiley.
7. Differential equation, Schaum series, Tata McGraw Hill.
8. Elements of Partial Differential Equation, I.N. Sneddom, Tata McGraw Hill.
9. Vector Analysis, N. Ch. S.N- Iyengar, Anmol Publication Pvt Ltd.
10. Advanced Engg. Mathematics, E. Kreyszig, John Wiely & Sons.

Course outcomes:

At the end of the course, the students would be able to:

CO1	Ability to understand the fundamentals of vector analysis
CO2	Capability to learn matrix algebra with its applications in chemical sciences
CO3	Understanding of probability ab initio
CO4	Fundamentals of differential calculus for use in chemical kinetics
CO5	Fundamentals of integral calculus for use in quantum chemistry
CO6	Understanding differential equations applied to chemical kinetics and quantum chemistry

Mapping of CO's with PO's

MCL-514(a)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	S	S	S	S	S	S	M
CO2	S	S	W	S	S	S	S	S	S	M
CO3	S	S	M	S	M	S	S	S	S	M
CO4	S	S	M	S	S	S	S	S	S	W
CO5	S	S	W	M	S	S	S	M	S	M
CO6	S	S	M	M	S	S	S	S	S	M

S = Strong; M = Medium; W = Weak

M.Sc. Chemistry, First Semester
Biology for Chemists

Course code: MCL-514(b)
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time: 2 Hrs **Total Marks: 50**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of three to four short answer type questions). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of biology for those students who were having mathematics in graduation.

Unit-I **7 Hrs**

Cell Structure and Functions

Structure of prokaryotic and eukaryotic cells, intracellular organelles and their functions, comparison of plant and animal cells. Overview of metabolic processes– catabolism and anabolism. ATP– the biological energy currency.

Unit-II **8 Hrs**

Carbohydrates

Introduction, structure and functions of important derivatives of monosaccharides like glycosides, deoxy sugars, myoinositol, amino sugars. N-acetylmuramic acid, sialic acid, disaccharides and polysaccharides. Structural polysaccharides – cellulose and chitin. Storage polysaccharides – starch and glycogen. Structure and biological functions of glucosaminoglycans or mucopolysaccharides. Glycoproteins and Glycolipids. Carbohydrate metabolism - Kreb's cycle, glycolysis, glycogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway.

Unit-III **7 Hrs**

Lipids

Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins. Lipoproteins-composition and function and role in atherosclerosis.

Properties of lipid aggregates-micelles, bilayers, liposomes and their possible biological functions. Biological membranes. Fluid mosaic model of membrane structure. Lipid metabolism.

Unit-IV **8 Hrs**

Proteins and Nucleic acid

Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing, geometry of peptide linkage. Secondary structure- α-helix, β-sheets, super secondary structure, Tertiary structure, Quaternary structure of proteins. Various forces responsible for stabalization of protein structure.

Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA and forces responsible for holding it.

Books Suggested:

1. Lehninger Principles of Biochemistry, M.M. Cox and D.L. Nelson, Freeman and Company.
2. Biochemistry, L. Stryer, W.H.F. Freeman.
3. Biochemistry, J. David Rawn, Neil Patterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry, E.E. Conn and P.K. Stumpf, John Wiley.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Explain about cells and their structure and functions overview of metabolic processes– catabolism and anabolism. ATP– the biological energy currency**.**

CO2 Explain the carbohydrates, their classification and carbohydrate metabolism - Kreb's cycle, glycolysis, glycogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway.

CO3 Explain fatty acids, essential fatty acids, structure, function, their properties and lipid metabolism.

CO4 Explain protein (structure, hydrolysis of protein and forces responsible for structure of proteins) and our genetic material (DNA, RNA their structure and function)

Mapping of CO with PO

MCL-514(b)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	W	S	S	S	M	S	S
CO2	S	S	M	W	S	S	S	W	S	S
CO3	S	S	M	W	S	S	S	W	S	S
CO4	S	S	M	W	S	S	S	W	S	S

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry, First Semester
Inorganic Chemistry Practical - I

Course code: MCP-515
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Water Analysis

1. Determination of dissolved oxygen in a water sample.
2. Determination of chemical oxygen demand of a waste water sample.
3. Determination of the amount of bleaching powder required to disinfect a water sample by Horrock's test.
4. Determination of total chlorine residuals.
5. Determination of free and combined chlorine residuals.
6. To determine the minimum dose of a coagulant required to coagulate a given sample by Jar test and to compare the effectiveness of aluminium sulphate and ferric sulphate as coagulants for a given sample at room temperature.
7. Determination of total suspended solids dried at 103-105°C
8. Determination of total dissolved solids dried at 180°C
9. Determination of fixed and volatile solids.
10. Determination of chloride content of a water sample by Mohr's Method.

II Preparations

Preparation of the following compounds:

1. $VO(acac)_2$
2. $NH_4[Cr(NH_3)_2(CNS)_4]$
3. $Mn(acac)_3$
4. $Na_3[Co(NO_2)_6]$
5. $Hg[Co(NCS)_4]$
6. $Cu_2[HgI_4]$

Books Suggested:

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS.
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, G. Svehla, Longman.
3. Practical Inorganic Chemistry, Marr and Rocket.
4. Applied Chemistry by O.P. Virmani and A.K. Narula, New Age International.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Perform water analysis experiment for the determination of solids, dissolved oxygen, COD, chloride content, chlorine residuals etc.
CO2 Prepare various coordination complexes.
CO3 Perform experiments and evaluate the results.
CO4 Compile interpreted information in the form of lab record.
CO5 Face /defend viva-voce examination.

Mapping of CO's with PO's
MCP-515

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	S	S	S	S	S
CO2	S	S	S	M	S	S	M	S	S	S
CO3	S	S	S	M	S	S	S	S	S	S
CO4	S	S	S	M	S	S	S	S	S	S
CO5	S	S	S	M	S	S	S	S	S	S

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry, First Semester
Organic Chemistry Practical - I

Course code: MCP-516
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Separation and Purification Techniques

Recrystallisation, Distillation: simple, fractional, steam and vacuum distillation, extraction, chromatography: thin-layer and column chromatography and Gas Chromatography.

II Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage learning.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
4. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
5. Vogel's Textbook of Practical Organic Chemistry, A.R. TatMCLl, John Wiley.

Course outcomes:
At the end of the course, the students would be able to:

CO1 Describe basic purification techniques in organic chemistry.
CO2 Explain basic principle and techniques of separation of binary organic mixture.
CO3 Analyse qualitatively the presence of extra elements and functional groups in the organic compound.
CO4 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record

Mapping of CO's with PO's
MCP-516

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	S	M	S	S
CO2	S	S	S	M	S	M	S	M	S	S
CO3	S	S	S	M	S	M	S	M	S	S
CO4	S	S	M	W	S	S	S	W	S	S

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry, First Semester
Physical Chemistry Practical - I

Course code: MCP-517
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Error Analysis and Statistical Data Analysis

1. Errors, types of errors, minimization of errors, error distribution curves, precision, accuracy and combination; statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F& Q test; linear regression analysis, curve fitting.
   Calibration of volumetric apparatus, burette, pipette and standard flask.

II Partition Coefficient

2. To study the distribution of benzoic acid between benzene and water at room temperature and show that benzoic acid dimerizes in benzene.

III Adsorption

3. To investigate the adsorption of oxalic acid from aqueous solutions by activated charcoal and examine the validity of Langmuir's adsorption isotherm.

IV Viscosity

4. To study the variation of viscosity of a liquid with composition of the mixture of liquids.

V Conductometry

5. Determination of the equivalent conductance of strong electrolytes such as HCl, KCl, KNO_3, $AgNO_3$, and NaCl and the validity of Onsager equation.
6. Study conductometeric titration of (1) HCl / NaOH (2) CH_3COOH / NaOH and comment on nature of graph.
7. Study conductometeric titration of (1) HCl/NH_4OH (2) CH_3COOH / NH_4OH and comment on nature of graph
8. Determine the equivalent conductance, degree of dissociation and dissociation constant of acetic acid.
9. Determine the equivalent conductance at infinite dilution for acetic acid by applying Kohlrausch's law of independent migration of ions.

VI pH– metry

10. To determine the strength of strong acid by titrating against strong base.
11. To determine the strength of strong acid by titrating against weak base.
12. To determine the strength of weak acid by titrating against strong base.

VII Colorimetry/Spectrophotometry

13. Verification of the Lambert-Beer's law using solutions such as $K_2Cr_2O_7$, $KMnO_4$, $CuSO_4$ in water, I_2 in CCl_4.

VIII Chemical Kinetics

14. Determine the rate constant of hydrolysis of an ester such methyl acetate catalyzed by an acid. Determine its energy of activation.

IX Polarimeter

15. To determine specific and molecular rotation of an optically active substance.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman.
2. Practical Physical Chemistry, B.P. Levitt and Zindley's, Longman.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill.

Course outcomes:

At the end of the course, the students would be able to:

CO1	Determine partition coefficients, adsorption and viscosity
CO2	Explain ion-ion interactions.
CO3	Use instruments like conductometer, pH-meter and viscometer etc.
CO4	Know the basics of kinetics of chemical reactions and determine the rates of reactions.
CO5	Determine the optical activity of the substances using polarimeter
CO6	Measure the conductance of electrolytes and application of Kohlrausch's law

Mapping of CO's with PO's

MCP-517

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	S	M	S	S
CO2	S	S	S	M	S	S	S	S	S	S
CO3	S	S	S	M	S	S	S	S	S	S
CO4	S	S	S	M	S	S	S	S	S	S
CO5	S	M	S	M	S	S	S	M	S	S
CO6	S	W	S	M	S	S	S	M	S	S

S=Strong; M=Medium; W=Weak

M.Sc. Chemistry

SECOND SEMESTER

M. Sc. Chemistry, Second Semester
Transition Metal Chemistry

Course code: MCL-521
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with electronic spectra, charge transfer spectra, magnetic properties and reaction mechanism of transition metal complexes.

Unit-I **15 Hrs**

Electronic Spectra of Transition Metal Complexes

Microstates, Spectroscopic ground states (Term symbols) and the evaluation of energies of various J states of free ions, Coupling Schemes, Term symbols for excited states, Energies of Terms, Racah Parameters, Selection rules, splitting of S, P, D and F terms under octahedral and tetrahedral electrostatic potential, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B, β and x parameters.

Unit-II **15 Hrs**

Charge Transfer Spectra and Magnetic Properties of Transition Metal Complexes

Charge transfer spectra of complexes (both metal to ligand and ligand to metal), Magnetic moment, various types of magnetism: Diamagnetism, Paramagnetism, Ferro and Anti ferromagnetism, effect of temperature and magnetic field on various types of magnetism

Metal-Ligand Equilibria in Solution

Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, MCLate effect and its thermodynamic origin.

Unit-III **15 Hrs**

Reaction Mechanism of Transition Metal Complexes - I

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage.

Unit-IV **15 Hrs**

Reaction Mechanism of Transition Metal Complexes- II

Substitution reaction in square planar complexes, the trans effect, theories of trans effect, Redox reactions or electron transfer reactions, complementary and non-complementary reactions, mechanism of one electron transfer reactions, outer sphere type reactions, outer sphere mechanism, factors affecting rate of outer sphere reactions, inner sphere type reactions, bridge mechanism and its consequences, evidences in favour of bridge mechanism.

Books Suggested:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huheey, Harper Collins.
3. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon.
4. Magnetochemistry, R.L. Carlin, Springer Verlog.
5. Introduction to Magnetochemistry, A. Earnshaw, Academic press.
6. Inorganic chemistry, G. Wulf'sburg, University science books.
7. Introduction to ligand fields, B.N. Figgis, Wiley Eastern.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Interpret electronic spectra of transition metal complexes based on Orgel /Tanabe-Sugano diagrams and selection rules.

CO2 Discuss charge transfer spectra and magnetic properties of transition metal complexes.

CO3 Describe the stability of metal complexes.

CO4 Discuss the ligand substitution reactions and their mechanism.

CO5 Explain the mechanism of acid and base hydrolysis.

CO6 Describe trans effect, electron transfer reactions and mechanism.

Mapping of CO's with PO's

MCL-521

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	S	M	W	S	S
CO2	S	S	S	M	M	S	M	W	S	S
CO3	S	S	W	M	M	S	S	M	S	S
CO4	S	S	M	M	S	S	S	M	S	S
CO5	S	S	M	M	S	S	S	M	S	S
CO6	S	S	S	M	S	S	S	M	S	S

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry, Second Semester
Structure and Mechanism in Organic Chemistry- II

Course code: MCL-522
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of structure and reaction mechanism in organic chemistry

Unit-I **15 Hrs**

Aromatic Electrophilic Substitution

The arenium ion mechanism, orientation and reactivity, ipso attack, Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

Aromatic Nucleophilic Substitution

The S_N^{Ar}, S_N1, benzyne and $S_{RN}1$ mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.

Aliphatic Electrophilic Substitution

Bimolecular mechanisms – S_E2 and S_E^i. The S_E1 mechanism, electrophilic substitution accompanied by double bound shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

Unit-II **15 Hrs**

Free Radical Reactions

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity in the attacking radicals. The effect of solvents on reactivity.

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. Hydrogenation of double and triple bonds. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

Unit-III **15 Hrs**

Addition to Carbon-Hetero Multiple Bonds

Mechanism of metal hydride reduction of carbonyl compounds, acids and esters. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl compounds. Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides.

Pericyclic Reactions-I

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5- hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams, FMO and PMO approach for Electrocyclic reactions, conrotatory and disrotatory motions, 4n, 4n +2 and allyl systems.

Unit-IV **15 Hrs**

Pericyclic Reactions- II

Woodward-Hoffmann correlation diagrams, FMO and PMO approach for Cycloaddition reactions, antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes. FMO and PMO approach for Sigmatropic rearrangements, suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3-and 5,5-sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Ene reaction.

Books Suggested:

1. March's Advanced Organic Chemistry-Reactions, Mechanisms and Structure, Michael B. Smith and Jerry March, Wiley-Interscience.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Springer.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, CBC Publisher & Distributors.
5. Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson.
6. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh revised by S.P. Singh and Om Prakash, Trinity.
7. Organic Chemistry, P.Y. Bruice, Pearson.
8. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
9. Pericyclic Reactions, S. Kumar, V. Kumar and S.P. Singh, Academic Press.
10. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Harcourt India Pvt. Ltd.
11. Organic Reaction Mechanism, V.K. Ahluwalia and R.K. Prasher, Narosa Publishing House.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Describe the aromatic and aliphatic electrophilic substitution reaction.
CO2 Explain the mechanisms of aromatic nucleophilic substitution including various rearrangements.
CO3 Describe the generation, structure, stability, reactivity of free radicals and addition to carbon-carbon multiple bonds.
CO4 Elucidate mechanism of reactions involving addition to C=O group of carbonyl compounds and acids.
CO5 Analyse the role of molecular orbitals in pericyclic reactions.
CO6 Determine the stereochemical course/product of a pericyclic reaction.

Mapping of CO's with PO's
MCL-522

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	W	M	S	S	W	S	S
CO2	S	M	S	M	S	S	S	M	S	S
CO3	S	M	S	M	S	S	S	M	S	S
CO4	S	M	S	M	S	S	S	M	S	S
CO5	S	S	S	W	M	S	S	W	S	S
CO6	S	S	S	W	S	M	M	W	S	S

S= Strong M= Medium W= Weak

M.Sc. Chemistry, Second Semester
Quantum Chemistry & Chemical Kinetics

Course code: MCL-523
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of Quantum Chemistry and Chemical Kinetics.

Unit – I **15 Hrs**

Quantum Chemistry-I

Introduction to Exact Quantum Mechanical Results

Hermition operators and their properties, commutation relations, postulates of quantum mechanics, uncertainty principle, Schrodinger equation and its interpretation.

Discussion of solutions of the Schrödinger equation to some model systems viz., particle in a box, simple harmonic oscillator, selection rules, expectation values, hydrogen atom and its complete solution, spherical harmonics as wave functions of rigid rotator, total wave functions of H-like atoms, shapes of atomic orbital.

Unit – II **15 Hrs**

Quantum Chemistry-II

Approximate Methods

The linear variation principle, Perturbation theory (first order and non-degenerate). Applications of variation method and perturbation theory to the Helium atom. Comparison of perturbation and variation methods.

Angular Momentum

Angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum.

Electronic Structure of Atoms

Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the p^n (n=2) configuration, term separation energies for the d^n (n=2) configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, Introduction to the method of self-consistent field, virial theorem.

Unit – III **15 Hrs**

Chemical Kinetics-I

Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.

Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-MCLorine reactions) and oscillatory reactions, homogenous catalysis, kinetics of enzyme reactions.

Unit – IV **15 Hrs**

Chemical Kinetics-II

Dynamics of unimolecular reactions (Lindemann–Hinshelwood and Rice - Ramsperger–Kassel – Marcus [RRKM] theories of unimolecular reactions).

General features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method.

Books Suggested:

1. Physical Chemistry, P.W. Atkins, Oxford University Press.
2. Introductory Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, I.M. Levine, Prentice Hall.
4. Chemical Kinetics, K.J. Laidler, McGraw Hill.
5. Physical Chemistry, G.W. Castellan, Narosa Publishers.
6. Quantum Mechanics, M.L. Strause, Prentice – Hall.
7. Chemical Kinetics Methods, C. Kalidas, New Age International.
8. Quantum Chemistry D.A. McQuarrie, Viva Books.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Understand basic concepts of quantum chemistry
CO2 Describe of wave functions and solution of Schrodinger equation for some models
CO3 Apply the approximate methods for solving multi-electron problem
CO4 Explain theories of reaction rates along with chain reactions
CO5 Acquaint with dynamics of unimolecular reactions along with the techniques for study of fast reactions
CO6 Understand the basic concepts of adsorption and equation related to it

Mapping of CO's with PO's
MCL-523

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	S	M	S	M
CO2	S	S	M	M	M	M	S	M	S	M
CO3	M	M	W	W	W	S	M	W	M	M
CO4	S	S	M	M	M	S	S	S	S	M
CO5	S	W	W	W	W	W	S	M	S	M
CO6	S	S	M	S	S	M	S	S	S	M

S=Strong; M=Medium; W=Weak

M.Sc. Chemistry, Second Semester
Symmetry and Spectroscopy

Course code: MCL-524
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of symmetry, group theory and physical aspects of molecular spectroscopy

Unit – I **15 Hrs**

Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh} etc. groups to be worked out explicitly).

Unit – II **15 Hrs**

Determination of point groups of molecules, reducible and irreducible representations, rules for finding out irreducible representations, direct product. The Great Orthogonality theorem (without proof) and its importance. Character tables and their use.

Unit – III **15 Hrs**

Basic Principles

Electromagnetic radiation, interaction of electromagnetic radiation with matter-absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels.

Microwave Spectroscopy

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor. nuclear and electron spin interaction.

Unit – IV **15 Hrs**

Vibrational Spectroscopy

Infrared Spectroscopy: Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P,Q,R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules, Selection rules, normal modes of vibration qualitative group frequencies, overtones, hot bonds, factor affecting the band positions and intensities NCA.

Raman Spectroscopy: Classical and quantum theories of Raman effect, Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Resonance Raman spectroscopy.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience.
3. Chemical Applications of Group Theory, F.A. Cotton, Wiley.

4. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, G.M. Barrow, McGraw Hill.
6. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
7. Fundamentals of molecular spectroscopy, C.N. Banwell, Tata Macgraw Hill.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Understand basic knowledge of symmetry and group theory in Chemistry
CO2 Assign the point groups to the molecules
CO3 Create the character table of various point groups and their application
CO4 Explain the interaction of electromagnetic radiation with matter
CO5 Describe the rotational and vibrational motions in molecules
CO6 Acquaint with basic principles of the Raman spectroscopy and its applications

Mapping of CO's with PO's

MCL-524

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	W	M	S	S	W	S	S
CO2	S	M	W	W	W	M	M	W	S	M
CO3	S	M	W	M	S	M	M	W	S	M
CO4	S	S	S	W	M	S	S	S	S	M
CO5	S	S	S	W	S	S	S	M	S	W
CO6	S	M	S	W	M	M	M	W	S	W

S = Strong; M = Medium; W = Weak

M.Sc. Chemistry, Second Semester
Inorganic Chemistry Practical -II

Course code: MCP-525
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Qualitative Analysis

Ten unknown mixtures will be given containing four radicals out of which one must be an insoluble and one may be an acid radical and two metal ions.

(a) Less common metal ions – Tl, Mo, W, Ti, Zr, Th, V, U (two metal ions in cationic/anionic forms)

(b) Insolubles– oxides (Al_2O_3, Cr_2O_3, SnO_2, TiO_2, SiO_2), sulphates ($PbSO_4$, $BaSO_4$) halides (AgCl, AgBr, AgI).

(c) Acid radicals CO_3^{2-}, HCO_3^-, SO_3^{2-}, SO_4^{2-}, CH_3COO^-,S^{2-}, PO_4^{3-}, NO_3^-, NO_2^-, Cl^-, Br^-, I^-, $C_2O_4^{2-}$ etc.

II Preparations

Preparation of the following compounds and their spectroscopic studies.

1. Potassium trioxalatoferate (III) Trihydrate.
2. Dichlorobis (hydroxylamine) Zinc (II).
3. Pentathioureadicuprous nitrate.
4. Potassium trioxaltochromate (III).
5. Potassium trioxalato cobaltate (III).
6. Carbonato tetra-ammine cobalt (III) nitrate.

Books Suggested:

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.
2. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
3. Inorganic Synthesis, Vol. 1-12, McGraw Hill.
4. Practical Inorganic Chemistry, Marr and Rocket.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Detect less common metal ions, insoluble salts and acidic radicals in mixture.
CO2 Prepare various coordination complexes.
CO3 Perform analysis and evaluate the results.
CO4 Compile interpreted information in the form of lab record.
CO5 Face /defend viva-voce examination

Mapping of CO's with PO's
MCP-525

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	S	S	S
CO2	S	S	S	S	S	S	S	S	S	S
CO3	S	S	S	M	S	S	S	S	S	S
CO4	S	S	S	M	S	S	S	S	S	S

CO5	S	S	S	M	S	S	S	S	S	S

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry, Second Semester
Organic Chemistry Practical - II

Course code: MCP-526
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Qualitative Analysis

Analysis of an organic mixture containing two solid components using HCl and ether for separation and preparation of suitable derivatives.

II Organic Synthesis

Preparation of organic compounds involving one step.
Acetylation: Acetylation of cholesterol.
Oxidation: Adipic acid from cyclohexanol.
Aldol condensation: Dibenzal acetone from benzaldehyde.
Sandmeyer reaction: *p*-Chlorotoluene from *p*-toluidine.

Other preparations involving one/two steps may be included.

Books Suggested:

1. Experiments in Organic Chemistry, L.F. Fieser, O.C. Heath Company
2. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall.
3. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath.
4. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
5. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
6. Vogel's Textbook of Practical Organic Chemistry, A.R. TatMCLl, John Wiley.

Course outcomes:

At the end of the course, the students would be able to:

CO1**.** Separate and analyze the binary organic solid mixture using HCl and ether.
CO2 Synthesise the organic compounds by acetylation, oxidation, aldol condensation etc
CO3 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record
CO4 Defend viva-voce

Mapping of CO's with PO's
MCP-526

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	S	M	S	S
CO2	S	S	W	M	S	M	S	M	S	S
CO3	S	S	M	W	S	S	S	W	S	S
CO4	S	S	S	W	M	S	W	M	S	S

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry, Second Semester
Physical Chemistry Practical - II

Course Code: MCP-527
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Potentiometry

1. Prepare and test the calomel electrode.
2. Titrate potentiometrically (1) HCl / NaOH (2) HCl / NH_4OH.
3. Titrate oxalic acid and sodium hydroxide potentiometrically.
4. Titrate Mohr's salt against $KMnO_4$ potentiometrically and carry out the titration in reverse order.

II Chemical Kinetics

5. Determine the velocity constant of hydrolysis of ethyl acetate using sodium hydroxide solution.

III Conductometry

6. Study conductometric titration of (1) NH_4Cl / NaOH (2) CH_3COONa / HCl and comment on nature of graph.
7. Study conductometric titration of (1) $MgSO_4$ / $Ba(OH)_2$ (2) $BaCl_2$ / K_2SO_4 and comment on nature of graph.
8. To study stepwise neutralization of polybasic acid i,e oxalic acid, citric acid, succinic acid by conductometric titration and explain the variation in the graph.
9. To determine the relative strength of two acids using conductometer.

IV pH– metry

10. To determine the hydrolysis constant of aniline hydrochloride.
11. Find out the dissociation constant of weak acid.

V Colorimetry/Spectrophotometry

12. Determine the concentration of $K_2Cr_2O_7$ and $KMnO_4$ in mixture of ($K_2Cr_2O_7$ + $KMnO_4$) solution.
13. Determine the concentration of Crystal violet and Aurine in mixture of (crystal violet + aurine) solution.

VI Polarimetry

14. To determine the concentration of an optically active substance.
15. To determine the percentage of two optically active substances in a given mixture.

VII Refractometer

16. To determine the refractive index of some liquids.
17. To determine the molar refractivity of CH_3OH, CH_3COOH, $CH_3COOC_2H_5$ and CCl_4 and calculate the refractive equivalent of C, H and Cl atoms.
18. Find out molar refractivity of benzene, toluene, propyl alcohol, butyl alcohol etc. and $–CH_2-$ group of homologous series.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.

4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
5. Experiments in Physical Chemistry, Shoemaker and Gailand, McGraw Hill.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Set up reference electrodes.
CO2 Determine conductance of electrolytes and application of Kohlrausch's law.
CO3 Evaluate dissociation behavior of electrolytes.
CO4 Verify Lambert-Beer's law.
CO5 Determine rate constant and activation energy of a chemical reaction
CO6 Analyze the optical activity of the substances.

Mapping of CO's with PO's
MCP-527

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	S	S	S	M	S
CO2	S	M	S	M	S	M	M	S	M	S
CO3	S	M	S	W	S	M	M	S	S	S
CO4	S	W	M	S	S	M	M	S	M	S
CO5	S	S	S	S	S	S	S	S	S	S
CO6	S	M	M	W	S	S	M	M	S	S

S=Strong; M=Medium; W=weak

M.Sc. Chemistry

THIRD SEMESTER

M.Sc. Chemistry, Third Semester
Applications of Spectroscopy

Course code: MCL-531
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the applications of different types of spectroscopy emphasizing more of structure elucidation.

Unit-I **15 Hrs**

Ultraviolet and Visible Spectroscopy

Various electronic transitions, Beer-Lambert law, visible spectrum & colour, factors effecting electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds, heterocyclic compounds and charge transfer complexes. Elementary ideas about phosphorescence, fluorescence, Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD).

Unit- II **15 Hrs**

Infrared Spectroscopy

Instrumentation and sample handling, Fermi resonance, effect of hydrogen bonding and solvent effect on vibrational frequencies, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds).

Unit- III **15 Hrs**

Nuclear Magnetic Resonance Spectroscopy

Introduction, chemical shift, spin-spin interaction, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), complex spin-spin interaction between two, three, four and five nuclei (first order spectra), Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra- nuclear magnetic double resonance, contact shift reagents and nuclear Overhauser effect (nOe).

Unit- IV **15 Hrs**

Carbon-13 NMR Spectroscopy

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroarmatic and carbonyl carbon), coupling constants and DEPT ^{13}C NMR spectra. General introduction to two-dimensional NMR spectroscopy - COSY. HSQC, HMBC, INADEQUATE and NOESY.

Mass Spectrometry

Introduction, ion production – EI, CI, FD and FAB, factors affecting fragmentation, McLafferty rearrangement, Nitrogen rule. Mass spectral fragmentation of organic compounds, common functional groups, molecular High-resolution mass spectrometry (HRMS).

Combined problems relating to structure elucidation by UV, IR, NMR Spectroscopy and Mass Spectrometry.

Books Suggested:

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
2. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
3. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.
4. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.
5. Organic Chemistry, William Kemp, John Wiley.
6. Organic Spectroscopy, Jag Mohan, Narosa Publishers, New Delhi
7. Spectroscopy, G.M. Lampman, D.L. Pavia, G.S. Kriz and J.M. Vyvyan, Cengage Learning.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Explain the origin of UV-visible bands, electronic transitions, Fieser-Woodward rules and photophysical properties of organic molecules.

CO2 Explain the basic principle and instrumentation of IR spectroscopy, characteristic vibrational frequencies of organic molecules.

CO3 Explain the basic principle of NMR spectroscopy, chemical shift, spin-spin interactions and simplification of complex spectra of different compounds.

CO4 Explain the basics of ^{13}C NMR spectroscopy, chemical shift in different organic compounds, DEPT, 2-D NMR spectroscopy.

CO5 Describe the basic idea of Mass spectrometry, methods of ion production, and fragmentation pattern of organic compounds.

CO6 Apply the knowledge of UV, IR, NMR and Mass spectrometry for structural elucidation of organic compounds.

Mapping of CO's with PO's
MCL-531

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	W	S	S	S	W	S	M
CO2	S	S	S	W	S	S	S	W	S	M
CO3	S	S	S	W	S	S	S	W	S	M
CO4	S	S	S	W	S	S	S	W	S	M
CO5	S	S	S	W	S	S	S	W	S	M
CO6	S	M	S	W	S	S	S	W	S	S

S= Strong, M = Medium, W= Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Third Semester
Organometallic Chemistry

Course code: MCL-532 (IC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the basics of bonding of transition metal compounds and catalysis.

Unit – I **15 Hrs**

Alkyls and Aryls of Transition Metals

Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis.

Compounds of Transition Metal-Carbon Multiple Bonds

Alkylidenes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

Unit – II **15 Hrs**

Transition Metal- π-Complexes

Transition metal π-complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, cyclopentadienyl (nature of bonding of ferrocene, MO description and aromatic character), arene and trienyl complexes, preparations, properties, nature of bonding and structural features.

Unit – III **15 Hrs**

Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^2- olefins, η^3- allyl and dienyl complexes.

Transition Metal Compounds with Bonds to Hydrogen

Bridging hydrides, dihydrogen complexes, synthesis and reactivity of hydride complexes.

Unit - IV

Homogeneous Catalysis **15 Hrs**

Homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), water gas shift reaction, Fischer tropsch process, oxopalladation reactions.

Books Suggested:

1. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley.
3. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.
4. Organometallics, A. Salzer, Ch. Elschenbrioch.VCH Publications.

Course outcome:

At the end of the course students will be able to:

CO1 Discuss synthesis and reactivity of alkyls and aryls of transition metals and their applications in organic synthesis.
CO2 Describe synthesis, properties and structure of carbene and carbyne complexes.
CO3 Explain the chemistry of transition metal- π-complexes
CO4 Explain the concept of fluxionality and dynamic equilibria in organometallic compounds.
CO5 Describe the synthesis, reactivity of hydrides and dihydrogen complexes.
CO6 Explain the concept of homogeneous catalysis.

Mapping of CO's with PO's
MCL-532 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	M	S	S
CO3	S	S	S	S	S	S	S	M	S	S
CO4	S	S	S	S	M	S	S	M	S	S
CO5	S	S	S	S	S	S	S	M	S	S
CO6	S	S	S	S	S	S	S	M	S	S

S= Strong, M = Medium, W= Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Third Semester
Chemical Analysis and Inorganic Spectroscopy

Course Code: MCL-533 (IC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with practical aspects of chemical analysis and concepts of spectral methods.

Unit – I **15 Hrs**

Practical Aspects of Chemical Analysis

Role of analytical chemistry, classification of analytical methods-classical and instrumental, types of instrumental analysis, selecting an analytical method, volumetric glassware-cleaning and calibration of glassware, sample preparations - dissolution and decompositions, desiccators and desiccants, filtration and ignition of solids, selecting and handling of reagents and other chemicals, safety in the analytical laboratory.

Errors and Evaluation- Definition of terms - mean and median, precision, standard deviation, accuracy. Errors – systematic (determinate), random (indeterminate), gross, errors in measurement, sources of errors and the effects upon the analytical results and its minimization.

Methods for reporting analytical data, Statistical evaluation of data, uses of statistics.

Unit – II **15 Hrs**

Atomic Absorption Spectroscopy

General principle, instrumental set up and analytical set up, measurement of atomic absorption and emission, analytical procedures of absorption and emission spectroscopy, sensitivity, detection limits, interference, applications.

Flame Photometry

Principles of flame photometry (flame emission spectroscopy), type of instruments, experimental technique, chemical reactions in flame, ionization in flames, spectra of metals in flames and applications.

Unit – III **15 Hrs**

Molecular Fluorescence Spectroscopy

Theory of molecular fluorescence, effect of concentration on fluorescence intensity, fluorescence instruments, application of fluorescence methods.

Molecular phosphorescence spectroscopy, chemiluminescence methods.

Unit – IV **15 Hrs**

Electron Spin Resonance Spectroscopy

Theory of ESR, instrumentation, ESR Spectra of DPPH, g value and factors affecting ESR lines, Hyperfine coupling, Hyperfine splitting constant, Zero field splitting and Kramer's degeneracy, applications of ESR, study of free radicals and inorganic compounds.

Mossbauer Spectroscopy

Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (i) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (ii) Sn^{+2} and Sn^{+4} compounds – nature M-L bond, coordination number, structure and (iii) detection of oxidation state and inequivalent MB atoms.

Books suggested:

1. Analytical Chemistry, G.D. Christian, J. Wiley.
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, W.B. Saunders.
3. Analytical Chemistry-Principles, J.H. Kennedy, W.B. Saunders.
4. Analytical Chemistry-Principles and Techniques, L.G. Hargis, Prentice Hall.
5. Principles of Instrumental Analysis, D.A. Skoog, J.L. Loary, W.B. Saunders.
6. Instrumental Methods of Analysis, H.H.Willard, L.L. Merrit, J.A. Dean, F.A. Settle, CBS Publishers.
7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.

Course outcomes:

At the end of the course students will be able to:

CO1	Demonstrate various statistical parameters and safety during practical aspects of chemical analysis.
CO2	Describe the principle, instrumentation, applications of atomic absorption spectroscopy and flame photometry.
CO3	Explain the working phenomenon of fluorescence and phosphorescence along with various factors related to these processes.
CO4	Explain electron spin resonance spectroscopy and its applications.
CO5	Describe the principle and spectral parameters of Mossbauer spectroscopy along with study of bonding and structure of iron and tin compounds.
CO6	Demonstrate various statistical parameters and safety during practical aspects of chemical analysis.

Mapping of CO's with PO's
MCL-533 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	M	S	S
CO3	S	S	S	S	M	S	S	M	S	S
CO4	S	S	S	M	M	S	S	M	S	S
CO5	S	S	S	M	M	S	S	M	S	S

S= Strong, M = Medium, W= Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Third Semester
Inorganic Chemistry Practical-III

Course code: MCP-534 (IC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

Quantitative Analysis

To carry out separation of
1. Copper and Nickel and estimation of Copper volumetrically and Nickel gravimetrically.
2. Copper and Zinc and estimation of Copper gravimetrically and Zinc volumetrically.
3. Iron and Magnesium and estimation of Iron volumetrically and Magnesium gravimetrically.
4. Iron and Nickel and estimation of Iron gravimetrically Nickel gravimetrically.
5. Silver and Nickel and estimation of Silver volumetrically and Nickel gravimetrically.
6. Copper and Barium and estimation of Copper gravimetrically and Barium gravimetrically.
7. Silver and Magnesium and estimation of Silver gravimetrically and Magnesium gravimetrically.
8. Copper and Magnesium and estimation of Copper gravimetrically and Magnesium gravimetrically.
9. Silver and Zinc and estimation of Silver volumetrically and Zinc gravimetrically.
10. Silver and Copper and estimation of Silver gravimetrically and Copper gravimetrically.

Books Suggested:

1. Synthesis and Characterization of Inorganic Compounds. W.L. Jolly, Prentice Hall.
2. Synthesis and Physical studies of Inorganic compounds C.F. Bell, Pergamon Press.
3. A Textbook of Quantitative Analysis. A.I. Vogel, ELBS, London.

Course outcomes:
At the end of the course, the students would be able to:

CO1	Quantitatively analyse and calculate strength of various metals.
CO2	Perform analysis and evaluate the results.
CO3	Compile interpreted information in the form of lab record.
CO4	Face /defend viva-voce examination.

Mapping of CO's with PO's
MCP-534 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	S
CO2	S	S	S	M	S	S	M	M	S	S
CO3	S	S	S	S	S	S	M	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S

S= Strong, M = Medium, W= Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Third Semester
Inorganic Chemistry Practical-IV

Course code: MCP-535 (IC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Spectrophotometric/Colorimetric determinations

1. To determine the strength of Cu (II) using EDTA.
2. To determine the strength of Fe (III) using EDTA.
3. Titration of Fe (II) against potassium permanganate.
4. To determine the concentration of nickel in given solution.
5. To analyse the given mixture of Cu (II) and Bi (III).
6. To determine simultaneously the As (III) and Sb (III) in the given mixture.
7. To determine the concentration of chloride ion.
8. To determine the concentration of sulphate ion.

II Chromatographic separations

9. Thin- layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of R_f values.
10. Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of R_f value.

III Flame photometric determinations

11. To determine the concentration of sodium in the given solution.
12. To determine the concentration of potassium in the given solution.
13. To determine the concentration of calcium in the given solution.
14. To determine the concentration of lithium in the given solution.
15. To determine the concentration of sodium and potassium when present together.

IV Polarography

16. Determination of iodide using Hg (II) nitrate.
17. Determination of sulphate using lead nitrate.

Books Suggested:

1. Synthesis and Characterization of Inorganic Compounds. W.L. Jolly, Prentice Hall.
2. Synthesis and Physical studies of Inorganic compounds C.F. Bell, Pergamon Press.
3. A Textbook of Quantitative Analysis. A.I. Vogel, ELBS.

Course outcomes:

At the end of the course students will be able to:

CO1 Determine strength and concentration of metal ions spectrophotometrically and by flame photometry.
CO2 Separate and identify metal ions and sugars by Chromatographic techniques.
CO3 Determine anions using polarography.
CO4 Perform analysis and evaluate the results.
CO5 Compile interpreted information in the form of lab record.
CO6 Face /defend viva-voce examination.

Mapping of CO's with PO's
MCP-535 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	S	S	S	S
CO2	S	S	S	S	S	S	S	W	S	S
CO3	S	S	S	M	S	S	S	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S
CO5	S	S	S	S	S	S	S	S	S	S
CO6	S	S	S	S	S	S	S	S	S	S

S= Strong, M = Medium, W= Weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Third Semester
Heterocyclic Chemistry and Photochemistry

Course code: MCL-532 (OC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with (i). the nomenclature, methods of synthesis and reactions of smaller ring systems (heterocycles) containing one/ two heteroatoms, and (ii). basics of photochemistry, photochemical reactions of organic compounds containing double bond and carbonyl groups, and several photochemical name reactions.

Unit-I **15 Hrs**

Nomenclature of heterocyclic compounds

Systematic (Hantzsch-Widman) and replacement nomenclature for monocylic and fused ring systems containing heteroatom(s).

Three-membered heterocyclic compounds

General methods of synthesis and reactions including mechanism of aziridines, oxiranes and thiiranes.

Four-membered heterocyclic compounds

General methods of synthesis and reactions including mechanism of azetidines, oxetanes and thietanes.

Unit-II **15 Hrs**

Five-membered heterocycles containing two heteroatoms

Structures, comparison of basicity, general methods of synthesis and reactions (including mechanism) of pyrazoles, imidazoles, oxazoles, isoxazoles, thiazoles and isothiazoles.

Unit-III **15 Hrs**

Photochemical Reactions

Interaction of electromagnetic radiation with matter, excitations and excited states, fate of excited molecule (Jablonski diagram), quantum yield, transfer of excitation energy- sensitization and quenching.

Photochemistry of Alkenes

Intramolecular reactions of the olefinic bond– geometrical isomerization, sensitized cyclization reactions and rearrangement of 1,4-dienes (Di-π-methane rearrangement).

Unit-IV **15 Hrs**

Photochemistry of Carbonyl Compounds

Intramolecular reactions of carbonyl compounds– saturated, cyclic and acyclic, β, γ-unsaturated and α, β-unsaturated compounds. Cycloaddition to alkenes (Paterno-Buchi reaction).

Miscellaneous Photochemical Reactions

Photo-Fries rearrangement, Barton reaction, and Hofmann-Loffler-Freytag reaction.

Books Suggested:

1. Heterocyclic Chemistry Vol. 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag.
2. Heterocyclic Chemistry, J.A. Joule, ELBS.
3. The chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
4. Heterocyclic Chemistry, T.L. Gilchrist, Longman Scientific Technical.
5. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.
6. An Introduction to Heterocyclic Chemistry, R.M. Acheson, John Wiley.
7. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, Pergamon Press.
8. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern
9. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill.
10. Photochemistry, R.P. Kundall and A. Gilbert, Thomson Nelson.
11. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
12. Photochemistry of Organic Synthesis, J. D. Coyle, Royal Society of Chemistry.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Explain the nomenclature of monocylic and fused ring systems containing heteroatom(s).
CO2 Describe the methods of syntheses and the chemical reactions of smaller ring systems– three- and four-membered heterocyclic compounds.
CO3 Illustrate the basic character, methods of syntheses and reactions with mechanistic details of several five-membered heterocycles containing two heteroatoms.
CO4 Demonstrate the general processes involved in a photochemical change.
CO5 Explain the course of an organic photochemical reaction and identification of the product(s) with the type of functional group present in the organic molecules.
CO6 Describe the mechanistic details of some important photochemical name reactions.

Mapping of CO's with PO's
Paper: MCL-532 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	M	S	S	S	M	M	W
CO2	M	S	W	S	S	S	M	M	S	W
CO3	M	S	W	S	S	S	M	M	S	W
CO4	S	S	W	M	W	S	M	M	S	M
CO5	S	S	W	S	S	S	M	M	S	W
CO6	S	S	W	S	S	S	M	M	S	W

S-Strong, M-Medium, W-Weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Third Semester
Bioorganic and Natural Products Chemistry

Course code: MCL-533 (OC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the mechanism of action & applications of enzymes and study of natural products chemistry.

Unit-I **15 Hrs**

Enzymes

Introduction, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. classification of enzymes (suitable examples of reactions), Fischer's lock and key and Koshland's induced fit hypothesis, identification of active site by the use of inhibitors, affinity labeling. Enzyme kinetics, reversible and irreversible inhibition.

Unit-II **15 Hrs**

Mechanism of Enzyme Action

Transition-state theory, proximity and orientation effect, acid-base catalysis, covalent catalysis. Enzymatic mechanisms for chymotrypsin, and carboxypeptidase A.

Biotechnological Applications of Enzymes

Extraction and purification of enzymes, methods for immobilization of enzymes, application of immobilized enzymes.

Unit – III **15 Hrs**

Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Stereochemistry, synthesis and biosynthesis of the following representative molecules: Citral, α-Terpeneol, Farnesol and β-carotene.

Steroids

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, synthesis of Cholesterol, Testorosterone and Progesterone.

Unit – IV **15 Hrs**

Alkaloids

Introduction, nomenclature, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen Heterocyclic ring.

Stereochemistry, synthesis and biosynthesis of the following: Nicotine, Atropine and Quinine.

Books Suggested:

1. Understanding Enzymes, T. Palmer, Prentice Hall.
2. Enzyme Chemistry: Impact and Applications, Ed. Collin J. Suckling, Chapman and Hall.
3. Enzyme Mechanisms Ed, M.I. Page and A. Williams, Royal Society of Chemistry.

4. Immobilized Enzymes: An Introduction and Applications in Biotechnology, M.D. Trevan, John Wiley.
5. Enzymatic Reaction Mechanisms, C. Walsh and W.H. Freeman.
6. Biochemistry: The Chemical Reactions of Living Cells, D.E. Metzler, Academic Press.
7. Bioorganic Chemistry, G. Bertini and V. Lippard, Viva Low Priced Student Edition.
8. Natural products: Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longman.
9. Organic Chemistry, Vol. 2, I.L. Finar, ELBS.
10. Stereoselective Synthesis: A Practical Approach, M. Nogradi, VCH.
11. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers.
12. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Explain the chemical and biological catalysis, classification, properties, enzyme kinetics and inhibition of enzymes.
CO2 Describe the mechanisms of enzyme catalyzed reactions along with mechanism of action of chymotrypsin and carboxypeptidase A.
CO3 Explain the extraction, purification and immobilization of enzymes.
CO4 Elucidate the isoprene and special isoprene rule, general methods of structure determination of terpenoids and synthesis of citral, α-terpineol, and β-carotene.
CO5 Describe synthesis of cholesterol, testosterone and progesterone.
CO6 Explain the classification based on nitrogen heterocyclic ring of alkaloids, structure elucidation of alkaloids and synthesis of Nicotine, Atropine and Quinine.

Mapping of CO with PO's
MCL-533 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	M	S	S	S	M	S	M
CO2	S	S	W	M	S	S	S	M	S	M
CO3	S	S	M	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	S	M
CO5	S	S	S	S	S	S	S	M	S	M
CO6	S	S	S	S	S	S	S	M	S	M

S = Strong; M = Medium; W = weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Third Semester
Organic Chemistry Practical – III

Course code: MCP-534 (OC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time: 6 Hrs	**Total Marks: 100**

1. Qualitative Analysis

Separation of components of a binary (solid+solid, liquid+solid or liquid+liquid) organic mixture using physical and chemical methods. Characterization of the separated components with the help of chemical analysis and derivative formation.

2. Confirmation of the structures by spectral data

Confirmation of the structures of separated components of binary mixture using IR, NMR and MS spectral data (IR, NMR and MS spectra will be provided).

Books Suggested:

1. Vogel's Text Book of Practical Organic Chemistry by B.S. Furness et. al., Longman Group Ltd.
2. Elementary Practical Organic Chemistry by Arthur I. Vogel Longmans, Green and Co. 1958.
3. Experiments in Organic Chemistry by Louis F. Fieser O.C. Heath and Company Boston, 1955.
4. Practical Organic Chemistry' by Mann and Saunders.
5. A Handbook of Organic Analysis Qualitative and Quantitative" by H.T. Clarke and revised by B. Maynes, Edward Arnold (Pub.)., Ltd. London.
6. Systematic Qualitative Organic Analysis by H. Middleton, Edward Arnold (Publishers) Ltd.
7. Laboratory Manual in Organic Chemistry by R.K. Bansal, Wiley Eastern Ltd., New Delhi
8. Analytical Organic Chemistry, Jag Mohan, Narosa Publishers.
9. A Guide to spectroscopy in Organic Chemistry by PAVY.
10. Spectrometric Identification of Organic Compounds, Fifth Ed., R.M. Silverstein, G.S. Bassler and T.C. Morill, John Wiley and Sons, New York.
11. Organic Spectroscopy, 3rd Ed., by William Kamp. John Wiley & Sons.
12. Spectroscopic Methods in Organic Chemistry, D.H. William & Ian Fleming.

Course outcome

At the end of the course the students will be able to –

CO1 Explain the methods of separations of binary (liquid-liquid, liquid-solid or solid-solid) organic mixtures.

CO2 Identify different functional groups using qualitative analysis.

CO3 Demonstrate the significance of melting point and boiling point in structure elucidation of organic compounds.

CO4 Prepare derivatives of different organic functionalities.

CO5 Characterize the components of given organic compounds by interpreting their FT-IR, NMR and MS spectral data.

CO6. Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record

Mapping of CO's with PO's
MCP-534 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	S	W	S	S	M
CO2	S	M	M	S	S	S	W	W	S	M
CO3	S	M	M	W	M	S	W	M	S	M
CO4	S	M	M	S	M	S	W	S	S	M
CO5	S	S	S	S	M	S	S	W	M	M
CO6	S	S	M	W	S	S	S	W	S	S

S-Strong, M-Medium, W-Weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Third Semester
Organic Chemistry Practical-IV

Course code: MCP-535 (OC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Extraction of organic compounds from natural source
Isolation of caffeine from tea leaves.
Isolation of casein from milk.
Isolation of lactose from milk.
Isolation of piperine from black pepper.
Isolation of β-carotene from carrots.

II Chromatographic Technique
High Performance Liquid Chromatography and Flash Chromatography for qualitative and quantitative analysis of organic compounds.

III Synthesis and characterization of some organic compounds of medicinal interest

Books Suggested:

1. Experiments in Organic Chemistry, L.F. Fieser, O.C. Heath, Company.
2. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
4. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
5. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
6. Analytical Organic Chemistry, Jag Mohan, Narosa Publishers.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Isolate the active component from natural sources.
CO2 Explain the principles, instrumentation and applications of High-Performance Liquid Chromatography and Flash Chromatography.
CO3 Synthesize (under different reaction conditions) and characterize the compounds of medicinal interest.
CO4 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record
CO5 Defend viva-voce. `

Mapping of CO's with PO's
MCP-535 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	S	S	M	S	M
CO2	S	S	M	W	M	S	S	M	S	M
CO3	S	S	S	S	S	S	S	M	S	M
CO4	S	S	M	W	S	S	S	W	S	S
CO5	S	S	S	W	M	S	W	M	S	S

S = Strong; M = Medium; W = Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Third Semester
Surface Chemistry and Non-Equilibrium Thermodynamics

Course code: MCL-532 (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with concept of surface chemistry and non-equilibrium thermodynamics.

Unit-I

Surface Chemistry-I **15 Hrs**

Adsorption: The extent of adsorption: Physisorption and Chemisorption, adsorption isotherms (Langmuir, BET, Freundlich isotherms), rates of surface processes (adsorption and desorption), mobility on surfaces, biosensor analysis. Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), surface films on liquids (Electro-kinetic phenomenon).

Unit-II

Surface Chemistry-II **15 Hrs**

Heterogeneous catalysis: Mechanisms of heterogeneous catalysis– Langmuir-Hinshelwood mechanism, Eley-Rideal Mechanism, catalytic activity at surfaces, Catalysis in chemical industry.

General features, structure of surfactants in solution, influence of chain length and salt concentration, surfactant parameters, surface active agents, classification of surface-active agents, micellisation, hydrophobic interactions, critical micellar concentration, factors affecting CMC of surfactants, CMC temperature dependence, counter ions binding to micelles, thermodynamics of micellization-phase, solubilization, microemulsion, reverse micelles.

Unit – III

Non-Equilibrium Thermodynamics-I **15 Hrs**

Introduction to non-equilibrium thermodynamics: Basic concept of entropy production and uncompensated heat and their relation to various thermodynamic functions, Entropy production in closed and open systems, entropy balance in continuous and discontinuous systems, transformation properties of fluxes and forces, coupled and uncoupled reactions and conditions, relaxation process.

Unit – IV **15 Hrs**

Non-Equilibrium Thermodynamics-II

Transport phenomena across membranes, thermochemical effects, thermal osmosis, electro-kinetic effect, thermo-mechanical and electrical effects.

Onsager theory and reciprocal relations, Onsager's formalism of non-equilibrium thermodynamics for multicomponent diffusion-Fick's law of diffusion, conductivity of electrolyte solutions, Onsager's formalism for transport phenomenon in electrochemical systems

Books Suggested:

1. An Introduction to Chemical Thermodynamics, R.P. Rastogi and R.R. Misra, Vikas Publication
2. Physical Chemistry, P.W. Atkins, Oxford University Press.
3. Thermodynamics for Chemists, S. Glasstone, Affiliated East-West Press.
4. Non-Equilibrium Thermodynamics-principles and applications, C. Kalidas and M.V. Sangaranarayanan, McMillan.
5. Chemical Kinetics, K.J. Laidler, McGraw Hill.
6. Physical Chemistry of Surfaces, A.W. Adamson, John Wiley and Sons.

Course Outcomes

At the end of the course, the students would be able to:

CO1	Understand the basic concepts of adsorption phenomenon and isotherms.
CO2	Describe the mechanism of surface catalysis.
CO3	Acquaint with micellization and critical micelle concentration
CO4	Understand non-equilibrium thermodynamics and its phenomena.
CO5	Apply phenomenological laws/equations for non-equilibrium processes.
CO6	Explain transport phenomenon across the membrane

Mapping of CO's with PO's

MCL-532 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	M	S	S	M	M
CO2	S	S	S	S	S	M	S	S	M	M
CO3	S	M	M	S	S	S	M	S	M	M
CO4	S	M	W	M	M	W	M	M	M	M
CO5	S	S	S	M	M	W	W	M	M	M
CO6	S	S	M	S	S	M	S	W	M	M

S = Strong; M = Medium; W = Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Third Semester
Quantum Chemistry and Group Theory

Course code: MCL-533 (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with advance Quantum Chemistry & Group Theory.

Unit – I **15 Hrs**

Quantum Chemistry-I

VB and MO theory, effective Hamiltonian, Huckel theory of conjugated system, application to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene, benzene etc. introduction to Extended Huckel theory.

Unit – II **15 Hrs**

Quantum Chemistry-II

Electron density distribution in a molecule, determination of its stability, geometry and reactivity. SCF theory, Born-Oppenheimer approximation, Hartree method, Hartree Fock method, Roothan's equation, Hellmann-Feynman theorem and its applications to chemical bonding

Unit – III **15 Hrs**

Group Theory-I

Elements of Group theory, point groups, theory of representation, reducible & irreducible representations, construction of character tables, (review of Great Orthogonality theorem) cyclic groups, SALC, Projection operators, Carbocyclic systems and MO calculation using symmetry group theoretical methods for $(CH)_n$ systems, Viz, $C_3H_3^+$, C_4H_4, C_6H_6, C_8H_8.

Unit – IV **15 Hrs**

Group Theory –II

Symmetry simplification of Huckel MO method taking Hydrocarbon naphthalene, tetra methylenecyclobutane, Group theory and normal modes of vibration of polyatomic molecules, viz. H_2O, NH_3, BF_3 etc. IR and Raman activity of modes of vibration of molecules, symmetry control of electrocyclic reaction, cycloaddition reactions and sigmatropic reactions.

Books Suggested:

1. Quantum Chemistry, I.N. Levine, Prentice Hall of India.
2. Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
3. Chemical Application of Group Theory, F.A. Cotton Interscience.
4. Methods in Molecular Orbital Theory, A.G. Turner, Prentice Hall of India.
5. Group Theory and Symmetry in Chemistry, L.H. Hall, McGraw Hill.
6. Symmetry and Spectroscopy of Molecules, K.V. Reddy, New Age International.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Apply of Valence bond and molecular orbital theory
CO2 Apply quantum chemistry in molecular study
CO3 Draw character table of various point groups and their application
CO4 Elucidate symmetry group for carbocyclic systems
CO5 Describe modes of vibration of polyatomic molecules
CO6 Understand symmetry control of pericyclic reactions

Mapping of CO's with PO's
MCL-533 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	W	M	M	M	W	S	W
CO2	S	M	M	M	M	M	M	W	S	W
CO3	S	M	M	W	M	M	M	W	S	W
CO4	S	M	M	M	W	M	M	W	S	M
CO5	S	M	W	W	W	M	M	W	S	M
CO6	S	W	W	W	M	M	S	W	S	M

S=Strong; M=Medium; W=Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Third Semester
Physical Chemistry Practical - III

Course code: MCP–534 (PC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Potentiometry

1. Set up a calomel electrode (saturated) and measure its potential using the quinhydrone electrode as a reference.
2. Set up the following electrodes and measure their potentials. Obtain values for their standard electrode potentials.
   (a) Zn / $ZnSO_4$ (0.1M) (b) Cu / $CuSO_4$ (0.1M)
3. Titrate (HCl + CH_3COOH) solution potentiometrically and determine the concentration of each component in a mixture.
4. Titrate solution of (a) KCl / KI / KBr and (b) Mixture (KCl + KI + KBr) potentiometrically. Determine the concentration of each component in a mixture.
5. Titrate potentiometrically a solution of ferrous ions against $K_2Cr_2O_7$ carry out the titration in reverse order.
6. Titrate Phosphoric acid potentiometrically and comment on graph.
7.. Determine the solubility and solubility product of an insoluble salt AgX (X=Cl, Br, I) potentiometrically.
8. Determine the mean activity coefficient of 0.01M HCl solution.
9. Find out pH values of three buffer solution using (a) indicator (b) pH–Meter (c) Potentiometer.

II Chemical Kinetics

10. Investigate the muta rotation of Glucose catalysed by (a) an acid (b) base.
11. Investigate the inversion of cane sugar in presence of an acid.
12. Investigation of the reaction between hydrogen peroxide and hydrogen iodide.
13. Investigate the reaction between acetone and iodine.
14. Determine the order and velocity constant of the reaction between potassium persulphate and potassium iodide.

III Refractometry

15. Refractometric determination of the composition of solutions.
16. Determination of concentration of sugar in a solution refractometrically.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Knowledge about setting up of electrode
CO2 Measurement of potential of different electrodes
CO3 Determination of concentration of solutions by potentiometric titrations
CO4 Understanding of kinetic study of chemical reactions
CO5 Determination of order and velocity constant
CO6 Determination of composition of solutions by refractometer

Mapping of CO's with PO's

MCP–534 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	W	S	M	S	S	M	S	S	S
CO2	S	W	S	M	S	S	W	S	S	S
CO3	S	S	S	M	S	S	M	S	S	S
CO4	S	S	S	M	S	S	M	S	S	S
CO5	S	W	S	M	S	S	M	M	S	S
CO6	S	S	S	M	S	S	M	S	S	S

S = Strong; M = Medium; W = Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Third Semester
Physical Chemistry Practical - IV

Course code: MCP–535 (PC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 6 Hrs **Total Marks: 100**

I Conductometry

1. Determine the strength of (acetic acid + hydrochloric acid) by titrating against NaOH.
2. Determine the hydrolysis constant of aniline hydrochloride.
3. Titrate a moderately strong acid (salicylic acid) by
   (a) Salt line method (b) Double alkali method.
4. Titrate a mixture of (H_2SO_4 + CH_3COOH) against NaOH.
5. Determine of strength of (HCl + NH_4Cl) titrating against NaOH.
6. Estimate concentration of each component of a mixture of $AgNO_3$ and HNO_3 by titrating against NaOH conductometerically.

II Spectrophotometry/Spectroscopy

7. Determine of strength of Fe (II) titrating against $KMnO_4$.
8. Determine of strength of Fe (II) titrating against EDTA solution.
9. Study of absorption of picric acid on charcoal by using colorimeter.
10. Study of dissociation constant of phenolphthalein by colorimeter.
11. Record the UV Spectrum of a given compound (acetone) in cyclohexane:
    Assign the transitions by recording spectra in solvents of different polarities (H_2O, CH_3OH, $CHCl_3$, CH_3CN and 1,4-dioxane).
12. Record the UV spectra of Benzene, pyridine and pyrimidine in methanol. Compare and discuss the various transitions observed.
13. Experiment on formation and study of adsorption isotherm by UV.
14. Experiment on formation and study of micelles.

III Polarography

15. Record polarogram of a solution of KCl (0.1M) in absence and presence of 0.005% gelatin in the solution. Explain the nature of polarograms. Repeat the experiment after expelling the dissolved oxygen with a stream of nitrogen gas (5-10 mm). What do you conclude from the experiment?
16. Determine the half wave potential and diffusion current of Cd^{2+} (0.001M) + Zn^{2+} (0.001M) +KCl (0.1M) + gelatine (0.005%). Estimate the concentration of the ions in separate and mixed solutions.
17. Determine the half wave potential and diffusion current of Zn (II) ion and Cd (II) ion in (a) Cd^{2+} (0.001M) in KCl (0.1M) (b) Zn^{2+} (0.001M) in KCl (0.1M).

IV Polymer Chemistry

18. Measurement of phase transition, glass temperature, heat transitions in polymers.
19. Determination of molecular weight by viscosity/any other methods.
20. Kinetics of polymerization/ polymer degradation.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill.
6. Thermal Methods of Analysis: Principles, Application and Problems, P.J. Hains, Blackie Academic and Professional.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Determine concentration of mixtures/solutions by conductometric titrations
CO2 Formation and study of micelles
CO3 Study absorption and transitions behavior in complexes
CO4 Determine half wave potential of metal ionic solutions and their conc.
CO5 Determine the Mol. Wt. & Viscosity of polymers.
CO6 Determone heat & phase transitions in polymers

Mapping of CO's with PO's

MCP–535 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	W	S	M	S	S	M	S	S	S
CO2	S	W	S	M	S	S	W	S	S	S
CO3	S	S	S	M	S	S	M	S	S	S
CO4	S	S	S	M	S	S	M	S	S	S
CO5	S	W	S	M	S	S	M	M	S	S
CO6	S	S	S	M	S	S	M	S	S	S

S = Strong; M = Medium; W = Weak

M.Sc. Chemistry, Third Semester
Seminar

Course code: MCS-536
60 Hrs (4 Hrs/week) **Total Marks: 50**
Credit: 2

All the students will submit the topic (Topic should be from M.Sc. Chemistry/UGC-CSIR NET/GATE syllabus) for the seminar in the begining of 3rd semester. The Committee constituted by the Chairperson for the evaluation of seminar will notify the schedule/dates of seminar. The student is required to present the seminar on the selected topic through power point presentation and submit the hard copy of the same to the committee.

Open Elective (OE) for the students of other departments

Introduction to Spectroscopy

Course code: MCL-537 (OE)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with basics and important applications of different techniques of spectroscopy.

Unit- I 15 Hrs

Ultraviolet and Visible Spectroscopy

Brief review of electromagnetic spectrum and absorption of radiation, factors affecting the position of UV bands, Various electronic transitions, Beer-Lambert law, visible spectrum & colour, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.

Unit- II 15 Hrs

Infrared Spectroscopy

Introduction, basic principles, Instrumentation and sample handling. 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.

Unit-III 15 Hrs

Nuclear Magnetic Resonance Spectroscopy

General introduction and definition, chemical shift, factors affecting chemical shift, solvents, spin-spin interaction, shielding and deshielding mechanism, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), deuterium exchange, nuclear Overhauser effect (nOe).

Unit-IV 15 Hrs

Mass Spectrometry

Basic principles and instrumentation, ion production– EI, CI, FD and FAB, MALDI, factors affecting fragmentation, ion analysis, ion abundance, molecular ion peak, metastable peak, McLafferty rearrangement, Nitrogen rule. Mass spectral fragmentation of organic compounds, common functional groups.

Books Suggested:

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
2. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.

3. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.
4. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.
5. Organic Spectroscopy, William Kemp, John Wiley.
6. Organic Spectroscopy, Jag Mohan, Narosa Publishers.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Explain the origin of UV-visible bands, electronic transitions, Fieser-Woodward rules and ultraviolet spectra of aromatic and heterocyclic compounds.

CO2 Explain the basic principle and instrumentation of IR spectroscopy, characteristic vibrational frequencies of organic molecules.

CO3 Explain the basic principle of NMR spectroscopy, shielding or deshielding effects, spin- spin interactions, chemical shift, deuterium exchange and nuclear Overhauser effect.

CO4 Describe the basic idea of Mass spectrometry, methods of ion production, and fragmentation pattern of organic compounds.

Mapping of CO's with PO's
MCP-537 (OE)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	W	S	S	S	W	S	M
CO2	S	S	S	W	S	S	S	W	S	M
CO3	S	S	S	W	S	S	S	W	S	M
CO4	S	S	S	W	S	S	S	W	S	M

S= Strong, M = Medium, W= Weak

M.Sc. Chemistry

FOURTH SEMESTER

M.Sc. Chemistry, Fourth Semester
Instrumental Methods of Analysis

Course code: MCL-541
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with instrumental methods for characterization and analysis of materials.

Unit-I **15 Hrs**

Chromatographic Methods

Classification of chromatographic methods, separation and development procedure, theoretical principles, factors influencing retention, retention and equilibrium in chromatography, separating efficiency of a column and resolution, Principle of gas chromatography, instrumentation, column and stationary phases, application and advances, Hyphenated techniques- GCMS, principle of HPLC, instrumentation and application, and LCMS.

Unit-II **15 Hrs**

Thermo-Analytical Methods

Theory, instrumental requirements and methodology for thermo gravimetric analysis (TG), differential thermal analysis (DTA) and differential scanning calorimeter (DSC), applications in organic, inorganic chemistry and polymers. Hyphenated techniques (TG-FTIR, TG-GC) and advantages

Unit-III **15 Hrs**

Diffraction Methods

Bragg condition, Miller indices, Bragg method, Debye-Scherrer method (sodium chloride crystal), indexing reflections for a cubic system using powder method. identification of unit cells from systematic absences in diffraction pattern. Structure factor and its relation to intensity and electron density, introduction to phase problem. Description of the procedure for an X-ray structure analysis (NaCl).

Introduction to electron diffraction, low energy electron diffraction and neutron diffraction.

Unit-IV **15 Hrs**

Advance Methods

Principles, instrumentation and applications of scanning probe microscopy, auger, scanning electron microscopy (SEM), Energy-dispersive *X*-ray spectroscopy (EDX), scanning tunnelling microscopy (STM), transmission electron microscopy (TEM), atomic force microscopy (AFM), X-ray fluorescence spectroscopy (XRF).

Books suggested:

1. Principles of Instrumental analysis, Skoog, Holler, Niemen, Saunders college publication.
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Cengage Learning.
3. Instrumental Methods of Analysis, H.H Willard, L.L. Merrit, J.A. Dean and F.A. Settle, CBS Publishers.
4. Thermal Methods of Analysis: Principles, Application and Problems, P.J. Hains, Blackie Academic and Professional.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Explain the classification, principle, instrumentation and application of chromatographic methods.

CO2 Learn about the methodology of thermo gravimetric analysis (TGA), differential thermal analysis (DTA) and differential scanning calorimetry (DSC),

CO3 Explain principles and applications of thermal analytical methods in various fields of chemistry.

CO4 Learn diffraction methods and patterns, to identify unit cells and discretion of X –Ray structure analysis.

CO5 Understand electron, low electron and neutron diffraction methods.

CO6 Learn about the instrumentation and phenomenon of advance methods of analysis like SPM, SEM, STM and TEM along with various factors related with these processes

Mapping of CO's with PO's
MCL-541

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	S	M	M	S	M
CO2	S	S	M	S	S	S	M	M	S	M
CO3	S	S	M	S	S	S	M	M	S	M
CO4	S	S	M	S	S	S	M	M	S	M
CO5	S	S	M	S	S	S	M	M	S	M
CO6	S	S	M	S	M	S	M	M	S	M

.

S=Strong; M=Medium; W=Weak

M.Sc. Chemistry, Fourth Semester
General Polymer Chemistry

Course code: MCL-542
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time: 2 Hrs **Total Marks: 50**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of three to four short answer type questions). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with basic aspects of polymer chemistry.

Unit-I **8 Hrs**

Basics and Polymerization

Introduction, classification and nomenclature of polymers, introduction to natural polymer, polymerization: condensation, addition, radical chain-ionic, coordination-Ziegler-Natta catalytic mechanism and copolymerization. Polymerization condition and reactions: polymerization in homogenous and heterogeneous systems- bulk, solution, suspension and emulsion polymerization.

Unit -II **7 Hrs**

Molecular Weight and Structure

Poly dispersion-average molecular weight concept: number and weight average; practical significance of molecular weight, measurement of molecular weights by viscometry, light scattering and osmotic pressure methods. Introduction to polymer dimension (end to end distance and radius of gyration). Glass transition temperature and its importance.

Unit -III **8 Hrs**

Synthesis, Properties and Applications of Polymers

Raw material of synthetic polymers, polyethylene, polypropylene, polystyrene, polyvinylchloride, nylon-6, phenolic and amino resins, polybutadiene rubber.

Unit-IV **7 Hrs**

Conducting Polymers

Introduction, classification, conduction mechanism, electrically and electronically conducting polymers, preparation of conducting polymer- polyacetylene, Poly(p-phenylene), factors affecting the conductivity, electrochemical polymerization, doping of conducting polymers and its significance.

Books Suggested:

1 Textbook of Polymer Science, F.W. Billmeyer (Jr), Wiley.
2 Principles of Polymer Chemistry, P. J. Flory, CornellUniversity Press.
3 Physical Chemistry of Polymers, A. Tager, Mir Publishers, Moscow.
4 Physical Chemistry of Macromolecules, Tanford
5 Polymers: Chemistry & Physics of Modern materials, J.M.G. Cowie, Blackie Academic.
6 Plastic Materials, J.A. Brydson, Butter worth Heinemann.
7 Principles of Polymerisation, G. Odian, John Willey.
8 Fundamentals of Polymer Processing, S. Middleman.
9 Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
10 Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R.M. Otta.

Course Outcomes

At the end of the course, the students would be able to:

CO1 Knowledge of polymers and natural polymers
CO2 Develop understanding of molecular weight measurement
CO3 Introduction to polymer dimension
CO4 Acquaintance with glass transition temperature and its importance
CO5 Familiarize with synthesis, properties and applications of various polymers
CO6 Understanding of conducting polymers and its significance

Mapping of CO's with PO's
MCL-542

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	S	M	S	W
CO2	S	S	M	S	S	S	S	W	S	W
CO3	S	S	M	S	S	S	W	M	S	W
CO4	S	S	M	S	S	S	S	M	S	W
CO5	S	S	M	S	S	S	S	W	S	W
CO6	S	S	M	S	W	S	S	M	S	W

S=Strong; M=Medium; W=Weak

M.Sc. Chemistry, Fourth Semester
Chemistry and Society

Course code: MCL-543

30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time: 2 Hrs **Total Marks: 50**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of three to four short answer type questions). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with interaction of Chemistry with Society.

Unit-I

Green Chemistry-I **8Hrs**

Introduction, different tools for green synthesis (elementary idea of green reagent, green solvent, green catalyst, solid phase, microwave and ultrasound assisted), atom economy, role of biocatalysts in green synthesis- enzyme catalyzed oxidation, reduction and hydrolytic reactions, synthesis involving basic principle of green chemistry- synthesis of adipic acid and BHC.

Unit-II

Green Chemistry-II **8 Hrs**

Renewable energy resources: fossil fuels, biomass, solar power, fuel cell; chemical from renewable feedstocks and fatty acid, polymer from renewable resources, some other chemicals from natural resource. Waste management: production, problem and prevention- Introduction, source of waste from chemical industry, waste minimization techniques, onsite waste treatment, design for degradation of DDT & surfactant, polymer recycling.

Unit -III **7 Hrs**

Introduction to industry products in daily use- perfumes, deodorants, skin care creams, hair colours and tooth pastes.

Brief introduction to IPR, need for patenting, conditions for invention to be patentable.

Weapons of mass destruction- Introduction, disarmament and peace.

UNIT-IV

Application of supermolecules **7Hrs**

Introduction, nature of supramolecular interactions, host-guest chemistry, solvation and hydrophobic effect. Application of supermolecules- Molecular device, molecular electronic and photonic devices, molecular computers and molecular machines.

Books Suggested:

1. Supramolecular Chemistry-Fundamental and application, K. Ariga and T. Kunitake, Springer.
2. Supramolecular Chemistry, J. W. Steed and J. L. Atwood, Wiley.
3. Green Chemistry: An introduction text, M Lancaster, RSC
4. Green Chemistry and Catalysis, R. A. Sheldon, I. Arends and V. Hanefield, Wiley-VCH.
5. IPR Handbook for Pharma Students and Researchers, P. Dixit, Pharma Med Press.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Explain the need of green chemistry, principles, atom economy and its application in synthesis.
CO2 Describe the elementary idea of green reagent, green solvent, green catalyst, solid phase, mw and ultrasound assisted reaction.
CO3 Explain the concept renewable energy resource and waste management.
CO4 Describe the industry products of daily use
CO5 Explain the IPR, need for patenting and invention to be patentable.
CO6 Explain the concept of supramolecular chemistry, host-guest chemistry and its applications.

Mapping of CO's with PO's
Paper: MCL-543

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	S	S	S	S	S	S	M
CO2	S	S	W	S	S	S	S	S	S	M
CO3	S	S	M	S	M	S	S	S	S	M
CO4	S	S	M	S	S	S	S	S	S	W
CO5	S	S	W	M	S	S	S	M	S	M
CO6	S	S	M	M	S	S	S	S	S	M

S = Strong; M = Medium; W = Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Fourth Semester
Photo and Bioinorganic Chemistry

Course code: MCL-544 (IC)

60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with photoinorganic chemistry and role of metal ions in biological systems.

Unit – I **15 Hrs**

Photoinorganic Chemistry

Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times-measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck – Condon principle, photochemical stages- primary and secondary processes, Electronically excited states of metal complexes. Photosubstitution, photooxidation and photoreduction, lability and selectivity.

Unit – II **15 Hrs**

Metal Ions in Biological Systems

Essential and trace metals. Role of metals ions in biological processes, Na^+/K^+ Pump.

Bioenergetics and ATP Cycle

DNA polymerisation, glucose storage, metal complexes in transmission of energy. Model systems.

Nitrogenase

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Unit - III **15 Hrs**

Transport and Storage of Dioxygen

Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, synthetic models.

Electron Transfer in Biology

Structure and function of metalloproteins in electron transport processes – cytochromes and ion-sulphur proteins, synthetic models.

Unit – IV **15 Hrs**

Mettaloenzymes

Zinc enzymes- carboxypeptidase and carbonic anhydrase. Iron enzymes- catalase, peroxidase and cytochrome P-450. Copper enzymes- superoxide dismutase. Molybednum oxatransferase enzymes- xanthine oxidase. Coenzyme vitamin B_{12}.

Metal Storage Transport and Biomineralization

Ferritin, transferrine and siderophores.

Books Suggested:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentne, University Science Books.
3. Bio-inorganic Chemistry, R.W. Hay; Ellis Harwood limited.
4. Metal ions in Biochemistry, P.K. Blattachary, Narosa Publishing House.
5. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fieischauer, Wiley.
6. Photochemistry of Coordination Compounds, V Balzari and V. Carassiti, Academic Press.

Course outcomes:

At the end of the course students will be able to:

CO1 Discuss photochemical laws, processes, energy dissipation and different types of photochemical reactions.

CO2 Explain role of metal ions in biological processes, DNA polymerization and nitrogen fixation.

CO3 Explain structure and functions of heme proteins in storage and transport of dioxygen.

CO4 Describe the structure, function and role of metalloproteins that are involved in electron-transfer reactions in biological systems and synthetic models.

CO5 Describe the metal storage, their transportation in living organisms and biomineralization.

CO6 Illustrate various metalloenzymes, their structure and mechanistic approach in various reactions occurring in living organisms.

Mapping of CO's with PO's
MCL-544 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	M	S	S
CO3	S	S	S	S	S	S	S	M	S	S
CO4	S	S	S	S	S	S	S	M	S	S
CO5	S	S	S	S	S	S	S	M	S	S
CO6	S	S	S	S	S	S	S	M	S	S

S= Strong, M = Medium, W= Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Fourth Semester
Chemistry of Materials

Course code: MCL-545 (IC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with inorganic polymers and materials.

Unit - I **15 Hrs**

Polyphosphazenes

Synthesis route and bonding features, ring opening mechanism for polyphosphazenes, Preparation of organo/ organometallic substituted phosphazenes and their applications.

Unit – II **15 Hrs**

Polysilanes

Preparation and characterization of polysilanes, sigma bond delocalization in polysilanes & its implications, applications of polysilanes.

Polysiloxanes

Method of synthesis by anionic and cationic polymerization properties & environmental aspects, structural flexibility, analysis and testing of polysiloxanes, industrial & medical application of Polysiloxanes.

Unit – III **15 Hrs**

Fibres

Carbon, boron, glass fibre synthesis, structural behavior and applications.

Glasses, Ceramics, composites and nanomaterials

Glassy state, glass formers and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Refractories, characterizations, properties and applications.

Microscopic composites, fibre-reinforced composites. Nanocrystalline phase, special properties, applications

Unit – IV **15 Hrs**

Polymeric Materials

Molecular shape, structure and configuration, crystallinity, stress-strain behaviour, thermal behaviour, polymer types and their applications, conducting and ferro-electric polymers.

Ionic Conductors

Types of ionic conductors, mechanism of ionic conduction, interstitial jumps (Frenkel); vacancy mechanism, superionic conductors, examples and applications of ionic conductors.

Books Suggested:

1. Inorganic Polymer, J.E. Mark.
2. Material Science and Engineering, An Introduction, W.D. Callister, Wiley.
3. Material Science, J.C. Anderson, K.D. Leaver, J.M. Alexander and R.D. Rawlings, ELBS.
4. Polymer Characterization, B.J. Hunt and James I. Mark.
5. Introduction to Macromolecular Science- Peter Munk.
6. Introduction to Polymer Science, R.J. Young and P.A. Lovell.
7. Polymer Synthesis (Vol. I-III), Starley R. Somdler and Wolfkaro.
8. Polymer Science and Technology, J.R. Fried, Prentice, Hall of India.
9. Principles of Polymer Chemistry, A. Ravve, Kluwer Academic Plenum Publishers.

Course Outcomes:

At the end of the course students are able to:

CO1 Describe synthesis, bonding features, ring opening mechanism for polyphosphazenes.
CO2 Explain preparation, characterization and applications of polysilanes.
CO3 Describe methods of synthesis, environmental aspects, structural flexibility, analysis, testing, industrial & medical application of Polysiloxanes.
CO4 Describe synthesis, structural behavior and applications of carbon and boron fibers.
CO5 Explain structure, properties and applications of ceramics, clay products, refractories, composites and Nanocrystalline phase.
CO6 Explain molecular shape, structure, configuration, crystallinity and related properties of conducting polymer and ionic conductors.

Mapping of CO's with PO's
MCL-545 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	S	S	M	S
CO2	S	S	S	M	S	S	S	S	M	S
CO3	S	S	S	M	S	S	S	S	M	S
CO4	S	S	S	M	S	S	S	M	M	S
CO5	S	S	M	S	S	S	S	M	M	S
CO6	S	S	M	W	S	S	S	W	M	S

S= Strong, M = Medium, W= Weak

Elective: SET-A
Inorganic Chemistry (IC)

M.Sc. Chemistry, Fourth Semester
Inorganic Chemistry Project

Course code: MCP-546 (IC)
180 Hrs (12Hrs /week) **Marks for Major Test (External): 105**
Credits: 6 **Marks for Internal Exam: 45**
Total Marks: 150

1. Each student has to carry out a project involving synthesis of inorganic/organometallic /transition metal compounds/ complexes.
2. Students must monitor the progress of the reaction and purity of final product(s) for all the stages of preparation by thin layer chromatography.
3. Characterization of synthesized compounds by melting point determination, molar conductance measurements and various spectroscopic techniques i.e. UV-VIS, IR, NMR etc.
4. Demonstration of different software useful in chemistry for drawing the structure of inorganic complexes as well as for the computational studies of synthesized complexes/compounds. Drawing of scheme for synthesis using structural drawing tool(s), getting the IUPAC name and predicted spectrum for each compound involved.
5. Introductory idea of Molecular Graphics, Molecular minimization, Energy minimization.

Books/References:

1. Vogel's Textbook of Quantitative Chemical Analysis, ELBS, London.
2. Synthesis and characterization of Inorganic Compounds W.L. Jolly, Prentice Hall.
3. Synthesis and Physical studies of Inorganic Compounds C.F. Bell, Pergamon Press.
4. Principles and application of Organotransition Metal Chemistry, J P Collmann, L S Hegsdus, J R Norton and R.G. Finke, University Science Books.
5. Spectrometric identification of organic compounds R.M. Silverstein, G.C. Bassler and T.C. Morill John Wiley.
6. Organic spectroscopy by Jag Mohan, Narosa Publication.
7. Application of Spectroscopy of organic Compounds, J R Dyer, Prentice Hall.
8. Spectroscopy, G.M. Lampman, D.L. Pavia, G.S. Kriz and J.M. Vyvyan, Cengage Learning.

Course outcomes:
At the end of the course the student will be able to:

CO1 Demonstrate the concept of synthesis of inorganic compounds/complexes.
CO2 Explore various combinations of reactions that can be exploited to form inorganic compounds/complexes.
CO3 Apply structural drawing tools such as ChemAxon, ChemDraw etc. for sketching the inorganic compounds, finding IUPAC nomenclature, NMR prediction and some useful physical properties of inorganic compounds.
CO4 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record
CO5 Defend viva-voce.

Mapping of CO's with PO's
Paper: MCP-546 (IC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	S	S	W	S	W
CO2	S	M	M	S	S	S	M	W	S	W
CO3	S	S	S	S	M	S	W	W	S	W
CO4	S	S	M	W	S	S	S	W	S	S
CO5	S	S	S	W	M	S	W	M	S	S

S-strong M-medium W-weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Fourth Semester
Organic Synthesis

Course code: MCL-544 (OC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the organic synthesis using different reagents, name reactions and disconnection approach.

Unit-I **15 Hrs**

Reagents in Organic Synthesis

Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details – lithium diisopropylamide (LDA) dicyclohexylcarbodimide (DCC), 1,3-Dithiane (reactivity umpoloung), trimethylisilyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, DDQ, Oxidation with Ruthenium tetraoxide, iodobenzene diacetate and thallium nitrate.

Unit - II **15 Hrs**

Reactions and Rearrangements

A detailed study of the following reaction- Favorskii, Arndt-Eistert synthesis, Baeyer-Villiger, Shapiro reaction, Chichibabin reaction. Mitsunobu reaction, Suzuki reaction, Buchwald-Hartwing reaction (cross-coupling), Sonogarshira reaction.

Unit-III **15 Hrs**

Disconnection Approach

An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X disconnections and two-group C-X disconnections, chemoselectivity, cyclisation reactions, amine synthesis.

Protecting Groups

Principles of protection of alcohol, amine, carbonyl and carboxyl groups.

Unit-IV **15 Hrs**

One Group C-C Disconnections

Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

Two Group C-C Disconnections

Diels-Alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, 1.5-difunctionalised compounds. Michael addition and Robinson annelation.

Books Suggested:

1. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Foundation Books.
3. March's Advanced Organic Chemistry-Reactions, Mechanisms and Structure, M.B. Smith and Jerry March, Wiley-Interscience.
4. Advanced Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Springer.
5. Designing Organic Synthesis, S. Warren, Wiley.
6. Organic Synthesis- Concept, Methods and Starting Materials, J. Fhrhop and G. Penzillin, Verlage VCH.
7. New Horizons in Organic Synthesis, Nair V, New Age International.
8. Reagents in Organic Synthesis, Fieser and Fieser, Wiley.
9. Organic Synthesis through disconnection approach, P.S. Kalsi, Medtec.
10. Comprehensive organic transformation, R.C. Larcock, Wiley-VCH.
11. Organic Chemistry, J.G. Smith, McGraw-Hill.

Course outcomes:

At the end of the course students are able to:

CO1 Describe the role of various reagents in organic transformations.
CO2 Explain the mechanistic details of different name reactions used for effective organic synthesis.
CO3 Describe the reactions catalyzed by palladium and their applications in organic synthesis
CO4 Apply the concepts of disconnection approach for the synthesis of different target organic molecules.
CO5 Explain the importance of order of events in synthesis and protection/deprotection in synthetic organic chemistry.
CO6 Describe alkene synthesis and use of acetylenes and aliphatic nitro compounds in organic synthesis.

Mapping of CO's with PO's
Paper: MCL-544 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	S	S	S	S	W	S	S
CO2	S	M	S	M	S	S	S	M	S	S
CO3	S	S	W	S	S	S	S	W	S	S
CO4	S	S	W	S	S	S	S	W	S	S
CO5	S	S	W	M	S	S	S	W	S	S
CO6	S	S	W	M	S	S	S	W	S	S

S= Strong M= Medium W= Weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Fourth Semester
Medicinal Chemistry

Course code: MCL-545 (OC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the drug design and development, synthesis and uses of medicinally important molecules of various classes.

Unit-I **15 Hrs**

Drug Design

Introduction, development of chemotherapeutic agents, therapeutic index, LD50 and ED50.Elementary idea about drug action: Concept of drugs receptor, elementary treatment of drug receptor interactions, ion channels and their control. Design of agonists, antagonists and partial agonists.

Drug development: concept of lead compounds. structure-activity relationships (SAR), synthetic analogues, isosteres and bioisosteres. Introductory idea of quantitative structure-activity relationships (QSAR).

Brief overview of pharmacokinetics and pharmacodynamics, concept of prodrug and synergism.

Unit-II **15 Hrs**

Analgesics, Antipyretics and Anti-inflammatory agents

Synthesis and uses of the following drugs: Morphine and related compounds (codeine and heroin), meperidine, methadone, aspirin, acetaminophen, indomethacin, phenylbutazone, mefenamic acid, ibuprofen and diclofenac.

Cardiovascular Drugs

Introduction, calcium channel blockers and β-blockers. Synthesis and uses of nitroglycerine, isosorbide dinitrate (sorbitrate), atenolol, diltiazem and verapamil.

Antifertility agents

Ovulation inhibitors and related hormonal contraceptives- norethindrone, norethynodrel, estradiol, mestranol; non-hormonal contraceptive- centchroman (synthesis of all the drugs excluded).

Unit-III **15 Hrs**

Antibiotics

Cell wall biosynthesis and protein synthesis inhibitors. Penicillins: Synthesis and uses of the penicillin G, problems of sensitivity to acids, β-lactamases and narrow spectrum of activity solved by leading to the development of oxacillin, cloxacillin, ampicillin and amoxicillin. Synthesis and uses of cephalosporin-C.

Introduction to azithromycin, tetracyclines and streptomycin (structures and uses only).

Antineoplastic Agents

Introduction, role of alkylating agents and antimetabolites in treatment of cancer. Synthesis and uses of the following antineoplastic agents: mechlorethamine, cyclophosphamide, melphalan, carmustin, 5-fluorouracil and 6-mercaptopurine. Introduction to paclitaxel (synthesis of paclitaxel excluded).

Unit-IV **15 Hrs**

Antimalarials

Introduction, Synthesis and uses of the following antimalarial drugs: chloroquine, primaquine and chloroguanide.

Antimycobacterial Drugs

Synthesis and uses of the following drugs: isoniazid, ethambutol and dapsone.

Antimicrobial Drugs

Antibacterial and antifungal agents, Synthesis and uses of ciprofloxacin and fluconazole.

Anxiolytics (Tranquilizers)

Synthesis and uses of diazepam, alprazolam and buspirone.

AIDS and drugs against HIV

HIV infection to the system, structure and uses of important drugs against HIV (nucleoside reverse transcriptase inhibitors) - AZT, ddI, ddC, d4T and 3TC (synthesis only of AZT).

Books Suggested:

1. An Introduction to Medicinal Chemistry, G.L. Patrick, Oxford University Press.
2. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, J.N. Delgado and W.A. Remers, Lippincott-Raven.
3. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
4. An Introduction to Drug Design, S.S. Pandeya and J.R. Dmmock, New Age International.
5. Burger's Medicinal Chemistry and Drug Discovery, Vol. 1, Ed. M E Wolff, John Wiley.

Course outcomes:

At the end of the course, the students would be able to:

CO1 Demonstrate the basic principles of design drug, action, and the terminology involved therein.

CO2 Describe the drug design for development of new drugs using rational approach to drug design, concept of lead compounds. structure-activity relationships (SAR), quantitative structure-activity relationships (QSAR).

CO3 Explain synthesis and medicinal uses of Analgesics, Antipyretics and Anti-inflammatory agents, and Cardiovascular drugs along with familiarity with Antifertility agent.

CO4 Illustrate the synthesis and medicinal uses of antibiotics as cell wall biosynthesis and protein synthesis inhibitors.

CO5 Describe synthesis and medicinal uses of Antineoplastic as alkylating agents, antimetabolites in treatment of cancer and Antimalarials, Antimycobacterial, Antimicrobial drugs and Anxiolytics (Tranquilizers).

CO6 Familiar with AIDS and drugs against HIV as nucleoside reverse transcriptase inhibitors.

Mapping of CO's with PO's
Paper: MCL- 545 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	W	M	W	S	S	W	S	W
CO2	S	S	W	M	W	S	S	W	S	W
CO3	S	S	W	M	S	S	S	W	M	W
CO4	S	S	W	M	S	S	S	W	M	W
CO5	S	S	W	M	S	S	S	W	M	M
CO6	S	S	W	M	S	S	S	W	M	W

S-Strong M-Medium W-Weak

Elective: SET-B
Organic Chemistry (OC)

M.Sc. Chemistry, Fourth Semester
Organic Chemistry Project

Course code: MRP-546 (OC)
180 Hrs (12Hrs /week) **Marks for Major Test (External): 105**
Credits: 6 **Marks for Internal Exam: 45**
Total Marks: 150

1. Each student has to carry out a project involving muti-step synthesis of organic compounds/organic compounds of medicinal interest.
2. Students must monitor the progress of reaction and purity of final product(s) for all the stages of preparation by Thin layer Chromatography.
3. Demonstration of different software useful in Chemistry for drawing the structure of Organic compounds as well as for the computational studies of small organic molecules.
4. Drawing of scheme for a multistep synthesis using structural drawing tool(s), getting the IUPAC name and predicted ^{1}H-NMR & ^{13}C-NMR spectrum for each compound involved in multistep preparation.
5. Introductory idea of Molecular graphics, Molecular minimization, Energy minimization and Spectral analysis.

Books Suggested:

1. Elementary Practical Organic Chemistry by Arthur I. Vogel Longmans, Green and Co. 1958.
2. Practical Organic Chemistry' by Mann and Saunders.
3. Text Book of Vogel's Practical Organic Chemistry by Longman Group, B.S. Furness et al., Ltd.
4. Experiments in Organic Chemistry by Louis F. Fieser O.C. Heath and Company Boston, 1955.
5. Organic Synthesis Collective Vol. I.
6. Laboratory Manual in Organic Chemistry by R.K. Bansal, Wiley Eastern Ltd., New Delhi-1980.

Course outcomes:
At the end of the course the student will be able to:

CO1 Demonstrate the concept of stepwise synthesis of a product and their purification
CO2 Explore various combinations of reactions that can be exploited to form organic products/compounds of medicinal interest and to have a knowledge of multistep reactions.
CO3 Apply structural drawing tools such as ChemAxon, ChemDraw etc. for sketching the organic compounds, finding IUPAC nomenclature, NMR prediction and some useful physical properties of small organic compounds.
CO4. Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record
CO5. Defend viva-voce.

Mapping of CO's with PO's
MCP-546 (OC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	S	S	W	S	W
CO2	S	M	M	S	S	S	M	W	S	W
CO3	S	S	S	S	M	S	W	W	S	W
CO4	S	S	M	W	S	S	S	W	S	S
CO5	S	S	S	W	M	S	W	M	S	S

S-Strong M-Medium W-Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Fourth Semester
Solid State and Biophysical Chemistry

Course code: MCL-544 (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the concepts of solid state and biophysical chemistry.

Unit – I 15 Hrs

Solid State Reaction

General principles, experimental procedures, co-precipitation as a precursor to solid-state reactions, kinetics of solid-state reactions.

Crystal Defects and Non-Stoichiometry

Perfect and imperfect crystals, intrinsic and extrinsic defects– point defects, line and plane defects, vacancies-Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry defects.

Unit – II 15 Hrs

Band Theory of Solids

Metals, insulators and semiconductors, electronic structure of solids-band theory, bank structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.

Optical properties– Optical reflectance, photoconduction-photoelectric effects.

Magnetic Properties– Classification of materials: Quantum theory of paramagnestics-cooperative phenomena-magnetic domains, hysteresius.

Organic Solids

Electrically conducting solids, organic charge transfer complex, organic metals and new superconductors.

Unit – III 15 Hrs

Bio-Physical Chemistry-I

Biological Cell and its Constituents: Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition.

Bioenergetics: Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

Statistical Mechanics in Biopolymers: Chain configuration of macromolecules, statistical distribution end-to-end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem.

Biopolymer Interactions: Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibrium and various types of binding processes in biological systems. Hydrogen ion titration curves.

Unit – IV **15 Hrs**

Bio-Physical Chemistry-II

Thermodynamics of Biopolymer Solutions: Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical nerve conduction.

Cell Membrane and Transport of Ions: Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamics treatment of membrane transport. Nerve conduction.

Biopolymers and their Molecular Weights: Molecular weight- Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, electrophoresis and rotational motions.

Books Suggested:

1. Biochemistry, L. Stryer, W.H. Freeman.
2. Biochemistry, J. David Rawn, Neil Patterson.
3. Biochemistry, Voet and Voet, John Wiley.
4. Lehninger Principles of Biochemistry, M.M. Cox and D.L. Nelson, Freeman and Company.
5. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, H. Dugas and C. Penny, Springer-Verlag.
6. Solid State Chemistry and its Applications, A.R. West Plenum.
7. Principles of the Solids State, H.V. Keer, Wiley Eastern.
8. Solid State Chemistry, N.B. Hannay.
9. Solid State Chemistry, D.K. Chakrabarty, New Age International

Course outcomes:

At the end of the course the student will be able to:

CO1 Rationalize general principles and kinetics of solid-state reactions
CO2 Distinguish crystal defects and non-stoichiometry defects
CO3 Rationalize the properties of materials such as conductivity, optical and magnetic
CO4 Understanding of biological cell and its constituents (protein, enzyme, DNA, RNA) and biopolymer interactions
CO5 Familiarize thermodynamics of biopolymer solutions
CO6 Estimate the molecular weights of biopolymers using different methods

Mapping of CO's with PO's

MCL-544 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	W	S	S	S	S	W	W	S	S
CO2	S	W	S	W	S	S	W	W	S	S
CO3	S	S	S	S	S	S	S	S	S	S
CO4	S	S	S	S	W	W	W	W	S	S
CO5	S	S	S	S	S	S	W	W	S	S
CO6	S	S	S	S	S	S	W	W	S	S

S = Strong; M = Medium; W = Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Fourth Semester
Physical Polymer Chemistry

Course code: MCL-545 (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time: 3 Hrs **Total Marks: 100**

Note: *The examiner is requested to set nine questions in all, selecting two questions from each unit and one compulsory question (Question No.1 based on entire syllabus will consist of seven short answer type questions each of two marks). The candidate is required to attempt five questions in all selecting one from each unit and the compulsory Question No.1.*

Objectives: This paper deals with the kinetics of polymerization, dimensions, state and physical properties of polymers.

Unit – I **15Hrs**

Kinetics of Polymerization

Introduction, Kinetics and statistics of step growth (condensation) polymerization, polyfunctional step-reaction polymerization, kinetics of radical chain (addition) polymerization, effect of temperature and pressure on chain polymerization, kinetics of ionic and coordination (addition) polymerization, kinetics of copolymerization.

Unit – II **15 Hrs**

Polymer Dimensions & Solutions

Average chain dimensions, freely jointed chain model, statistical distribution of end-to-end dimensions, chain stiffness, short range effects.

Polymer in solutions: thermodynamics of polymer solution, non-ideal solutions, Flory-Huggins theory, enthalpy change of mixing and free energy change of mixing, phase equilibria, fractionation, Flory-Krigbaum theory, theta temperature, lower and upper critical solution temperatures.

Unit – III **15 Hrs**

Polymer Stereochemistry

Introduction, orientation, configuration, geometric isomerism, conformation of stereoregular polymers, factors affecting stereo regulation, homogenous stereoselective and stereospecific cationic and anionic polymerizations.

Polymer State, Structure and Properties

Crystalline state: introduction, mechanism of crystallization, temperature and growth rate, melting, thermodynamic parameters, crystalline arrangement of polymers, morphology, kinetics of crystallization

Amorphous state: molecular motion, viscoelastic behaviour, effect of chain length, rubbry state and elastomeric state; glassy state, glass transition temperature (T_g), determination and factors affecting it, free volume theory, dependence of T_g on molar mass, relaxation process in glassy state.

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Unit – IV **15 Hrs**

Mechanical Properties

Mechanical Properties: viscoelastic state, mechanical properties, mechanical models describing viscoelasticity, linear viscoelastic behavior of amorphous polymers (creep, stress-strain and temperature effect), dynamic mechanical and dielectric thermal analysis (DMTA and DETA).

Elastomeric state

Introduction, thermodynamic aspects of rubber-like elasticity

Flow Properties of Polymer Melts

Terminology; effects on temperature, pressure and molecular weight on viscous flow properties, elastic effects in polymer melts.

Books Suggested:

1 Textbook of Polymer Science, F.W. Billmeyer (Jr), Wiley.
2 Principles of Polymer Chemistry, P J Flory, Cornell University Press.
3 Physical Chemistry of Polymers, A Tager, Mir Publishers, Moscow.
4 Physical Chemistry of Macromolecules, Tanford
5 Polymers: Chemistry & Physics of Modern materials, J.M.G. Cowie, Blackie Academic and Professional.
6 Plastic Materials, J.A. Brydson, Butter worth Heinemann.
7 Principles of Polymerisation, G. Odian, John Willey.
8 Fundamentals of Polymer Processing, S. Middleman
9 Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
10 Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R.M. Otta

Course outcomes:

At the end of the course the student will be able to:

CO1 Evaluate the Kinetics of polymerization
CO2 Elucidate polymer dimensions and thermodynamics of polymer solution
CO3 Understand the stereochemistry of polymers
CO4 Explain the polymer state and structure
CO5 Evaluation of mechanical properties of polymers
CO6 Describe flow properties of polymer melts

Mapping of CO's with PO's
MCL- 545 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	M	M	W	W	S	M
CO2	M	M	S	M	S	S	W	W	S	M
CO3	S	S	M	M	S	S	S	S	S	M
CO4	S	S	M	S	M	S	W	W	S	M
CO5	S	M	S	M	S	S	W	W	S	M
CO6	M	W	W	M	M	M	W	W	S	M

S=Strong; M=Medium; W=Weak

Elective: SET-C
Physical Chemistry (PC)

M.Sc. Chemistry, Fourth Semester
Physical Chemistry Practical-V

Course code: MRP-546 (PC)
180 Hrs (12 Hrs /week) **Marks for Major Test (External): 105**
Credits: 6 **Marks for Internal Exam: 45**
Total Marks: 150

Each student has to carry out one practical project by choosing one or two areas out of areas mentioned below. Student will perform experiments from ab initio to the advanced experiments of the chosen area(s) keeping in mind applications of the study. The experiments will be performed to measure physical properties of materials/solutions/solvents/reactions, validation of laws/phenomena, composition & structure determination, and study of interactions. Student will submit detailed report consisting theory, experimental set up, observations, discerption & results of all experiments done in sequence, highlighting their applications of the any chosen area(s).

1. Optical measurements in Chemistry (Refractometry, Polarimetery, Colorimetry, etc.),
2. Electrochemistry: (Electric conductance, transport numbers, e.m.f. and pH etc.)
3. Chemical kinetics (Solutions, solid state, polymerization, degradation)
4. Thermodynamics (Enthalpy, Free energy, Entropy, Partial molar properties, Excess functions etc.), 5. Surface Chemistry (Adsorption, surfactants etc), 6. Polarography Phase equilibria, 8. Polymer Chemistry, 9. Spectroscopy, 10. Sold State Chemistry 11. Advanced and Computational techniques etc.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman.
2. Practical Physical Chemistry, B.P. Levitt and Zindley's, Longman.
3. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
4. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill.
5. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.
6. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, W.B. Saunders.
7. Instrumental Methods of Analysis, H.H. Willard, L.L. Merrit, J.A. Dean, F.A. Settle, CBS Publ.
8. Polymer Characterization, B.J. Hunt and James I. Mark.

Course outcomes:
At the end of the course the student will be able to –

1. Expertise to conduct experiments for advanced study
2. Validate the laws/phenomena
3. Design and set up the experiments for measurements of properties
4. Use and apply advanced techniques
5. Characterization of compounds by advanced techniques
6. Understanding of computational techniques in solving problems in chemistry

Mapping of CO's with PO's
MRP-546 (PC)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	M	S	M	S	S
CO2	S	M	S	S	M	M	M	M	S	S
CO3	S	S	S	S	S	S	M	S	S	S
CO4	S	S	S	S	S	S	S	M	S	S
CO5	S	S	S	S	S	S	S	S	S	S
CO6	S	S	S	S	S	S	S	M	S	S

S = Strong; M = Medium; W = Weak

PROGRAMME SPECIFIC OUTCOMES (PSOs)

The programme specific outcomes (PSOs) are the statement of competencies/abilities that describes the knowledge and capabilities of the post-graduate will have by the end of programme studies.

PSO1	Understanding of theoretical concepts and experimental aspects of chemistry.
PSO2	Participate in different present and emerging areas of chemical sciences.
PSO3	Recognize, assess, plan, and carry out qualitative and quantitative analytical, synthetic, and phenomenon-based problems in the chemical sciences.
PSO4	Provide opportunities to excel in academic, research and industry.

MAPPING OF THE SUBJECT WITH THE FOLLOWINGS

Course Name	**Corse code**	**Employ ability**	**Entrepre neurship**	**Skill Development**
Bonding and Properties of Inorganic Compounds	MCL-511	√		√
Structure and Mechanism in Organic Chemistry-1	MCL-512	√		√
Thermodynamics and Electrochemistry	MCL-513	√		√
Mathematics for Chemists	MCL-514 (a)			√
Biology for Chemists	MCL-514 (b)			√
Inorganic Chemistry Practical - I	MCP-515		√	√
Organic Chemistry Practical - I	MCP-516	√	√	√
Physical Chemistry Practical - I	MCP-517	√	√	√
Transition Metal Chemistry	MCL-521	√		√
Structure and Mechanism in Organic Chemistry-II	MCL-522	√		√
Quantum Chemistry and Chemical Kinetics	MCL-523	√		√
Symmetry and Spectroscopy	MCL-524	√		√
Inorganic Chemistry Practical - II	MCP-525	√	√	√
Organic Chemistry Practical - II	MCP-526	√	√	√
Physical Chemistry Practical - II	MCP-527	√	√	√
Applications of Spectroscopy	MCL-531	√		√
Organometallic Chemistry	MCL-532 (IC)	√		√
Heterocyclic and Photochemistry	MCL-532 (OC)	√		√
Surface Chemistry and Non-Equilibrium Thermodynamics	MCL-532 (PC)	√		√
Chemical Analysis and Inorganic Spectroscopy	MCL-533 (IC)	√		√
Bioorganic and Natural Products Chemistry	MCL-533 (OC)	√		√
Quantum Chemistry and Group Theory	MCL-533 (PC)	√		√
Inorganic Chemistry Practical-III	MCP-534 (IC)	√	√	√
Organic Chemistry Practical-III	MCP-534 (OC)	√	√	√

Physical Chemistry Practical-III	MCP-534 (PC)	√	√	√
Inorganic Chemistry Practical-IV	MCP-535 (IC)	√	√	√
Organic Chemistry Practical-IV	MCP-535 (OC)	√	√	√
Physical Chemistry Practical-IV	MCP-535 (PC)	√	√	√
Open Eletive to be opted from other Departments **or** Massive Open Online Courses (MOOCs)	----	√		√
Seminar	MCS-536	√	√	√
Instrumental Methods of Analysis	MCL-541	√		√
General Polymer Chemistry	MCL-542	√		√
Chemistry and Society	MCL-543	√	√	√
Photo and Bioinorganic Chemistry	MCL-544 (IC)	√	√	√
Organic Synthesis	MCL-544 (OC)	√	√	√
Solid State and Biophysical Chemistry	MCL-544 (PC)	√	√	√
Physical Polymer Chemistry	MCL-545 (PC)	√	√	√
Inorganic Chemistry Project	MRP-546 (IC)	√	√	√
Organic Chemistry Project	MRP-546 (OC)	√	√	√
Physical Chemistry Project	MRP-546 (PC)	√	√	√