AWADHESH PRATAP SINGH
UNIVERSITY, REWA (M.P.)

SYLLABUS
FOR
M.Sc. CHEMISTRY
FOUR SEMESTERS
(TWO YEAR COURSE)

Effective from session 2015-16
# M.Sc. CHEMISTRY
## (FOUR SEMESTER COURSE)
### SCHEME OF EXAMINATION
#### M.Sc. (Previous)

**SEMESTER – I**

<table>
<thead>
<tr>
<th>Paper</th>
<th>Course No.</th>
<th>Course</th>
<th>Marks (Theory + CCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper I</td>
<td>MCH-401</td>
<td>Inorganic Chemistry I</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Paper II</td>
<td>MCH-402</td>
<td>Organic Chemistry I</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Paper III</td>
<td>MCH-403</td>
<td>Physical Chemistry I</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Paper IV</td>
<td>MCH-404</td>
<td>Group Theory, Mathematics for Chemists &amp; Biology for Chemists</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Practical *</td>
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<tr>
<td><strong>Total Marks</strong></td>
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* Practical Examinations will be held in second semester.

**SEMESTER – II**

<table>
<thead>
<tr>
<th>Paper</th>
<th>Course No.</th>
<th>Course</th>
<th>Marks</th>
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<tbody>
<tr>
<td>Paper V</td>
<td>MCH-405</td>
<td>Inorganic Chemistry II</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Paper VI</td>
<td>MCH-406</td>
<td>Organic Chemistry II</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Paper VII</td>
<td>MCH-407</td>
<td>Physical Chemistry II</td>
<td>100(80+20)</td>
</tr>
<tr>
<td>Paper VIII</td>
<td>MCH-408</td>
<td>Spectroscopy II and Diffraction Methods</td>
<td>100(80+20)</td>
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<td>Practical</td>
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<td>Inorganic + Organic + Physical</td>
<td>300</td>
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<tr>
<td><strong>Total Marks</strong></td>
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M.Sc. (Final)

SEMESTER– III

<table>
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<tbody>
<tr>
<td>Paper I</td>
<td>MCH-501</td>
<td>Applications of Spectroscopy I</td>
<td>100(80+20)</td>
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<tr>
<td>Paper II</td>
<td>MCH-502</td>
<td>Photochemistry</td>
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<td>Paper III</td>
<td>MCH-503</td>
<td>Polymer Chemistry</td>
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<td>Paper IV</td>
<td>MCH-504</td>
<td>Heterocyclic Chemistry</td>
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Practical*  
Total Marks  400

* Practical Examinations will be held in fourth semester.

SEMESTER– IV

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<tr>
<th>Paper</th>
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<tr>
<td>Paper V</td>
<td>MCH-505</td>
<td>Applications of Spectroscopy II</td>
<td>Compulsory</td>
<td>100(80+20)</td>
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<td>Paper VI</td>
<td>MCH-506</td>
<td>Solid State Chemistry</td>
<td>Compulsory</td>
<td>100(80+20)</td>
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<td>Paper VII</td>
<td>MCH-507</td>
<td>Natural Products</td>
<td>Compulsory</td>
<td>100(80+20)</td>
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<tr>
<td>Paper VIII</td>
<td>MCH-508-512</td>
<td>Optional Paper*</td>
<td>Optional</td>
<td>100(80+20)</td>
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<tr>
<td>Practical</td>
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<td>Inorganic + Organic + Physical</td>
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</table>

Project Work  150

Total Marks  850

Optional Paper*

MCH – 508: Organic Synthesis  
MCH – 509: Organotransition Metal Chemistry  
MCH – 510: Analytical Chemistry  
MCH – 511: Electrochemistry  
MCH – 512: Medicinal Chemistry

Grant Total Marks M.Sc. (Previous & Final) 1100 + 1250 = 2350
* Minimum passing marks in theory is 25 marks.
* Minimum passing marks in CCE is 10 marks.
* Instead of laboratory work, student may performed Project work.
(Sample for Question Papers)
M.Sc. I / II / III / IV
Chemistry
Paper: MCH- .......

Time allowed: Three hours
Maximum Marks: 75
Minimum Passing Marks: 25

Note:- This paper is divided into two Sections (A and B). Marks are indicated against each section. Read the instruction of each section carefully and answer accordingly.

Section – A
(Short Answer type Questions)

Note:- All questions are compulsory.

Unit – I
7 x 5 = 35

Q.1
Q.2

Unit – II

Q.3
Q.4

Unit – III

Q.5
Q.6

Unit – IV

Q.7
Q.8

Unit – V

Q.9
Q.10

Section B
(Long answer type questions)

Note:- Attempt any two Questions.
20 x 2 = 40

(One question from each Unit should be given)

Q.11
Q.12
Q.13
Q.14
Q.15
SEMIESTER –I
Paper-I
MCH-401: INORGANIC CHEMISTRY I

Unit-I
Stereochemistry and Bonding in Main Group Compounds:
VSEPR, Walsh diagram (triatomic and penta-atomic molecules), $d\pi-p\pi$ bond, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.

Unit-II
Metal-Ligand Equilibrium in Solution
Stepwise and overall formation constants and their interaction, trends in stepwise constant, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand. Chelate effect and its thermodynamic origin, determination of binary formation constants by potentiometry and spectrophotometry.

Unit-III
Reaction Mechanism of Transition Metal Complexes
Energy profile of a reaction, reactivity of metal complex, 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, anion reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Redox reaction, electron transfer reactions, mechanism of one electron transfer reactions, outer sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.

Unit-IV
Metal-Ligand bonding
Limitation of crystal field theory, molecular orbital theory for bonding in octahedral, tetrahedral and square planar complexes, $\pi$-bonding and molecular orbital theory.

Unit-V
HSAB Theory
Classification of acids and bases as hard and soft; HSAB principle, theoretical basis of hardness and softness; Lewis-acid base reactivity approximation; donor and acceptor numbers, $E$ and $C$ equation; applications of HSAB concept.

Books Suggested:
SEMESTER–I
Paper-II
MCH-402: ORGANIC CHEMISTRY I

Unit-I
Nature of Bonding in Organic Molecules
Delocalized chemical bonding-conjugation, cross conjugation, resonance hyperconjugation, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non-benzoid compounds, alternate and non-alternate hydrocarbons. Huckel’s rule, energy. Level of π-molecular orbitals, annulenes, anti-aromaticity, homo-aromaticity, PMO approach. Bonds weaker than covalent-addition compounds, crown ether complexes and cryptands, inclusion compounds, catenanes and rotaxanes.

Unit-II
Stereochemistry
Strain due to unavoidable crowding Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis, Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spirane chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Unit-III
Conformational Analysis and Linear Free Energy Relationship
Conformational analysis of cycloalkanes, decalines, effect of conformation on reactivity, conformation of sugars.
Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. The Hammett equation and linear free energy relationship, substituents and reaction constants, Taft equation.

Unit-IV
Reaction Mechanism: Structure and Reactivity
Type of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond’s postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotopes effects.

Unit-V
Aliphatic Nucleophilic Substitution
The SN2, SN1 mixed SN1 and SN2 and SET mechanism. The neighboring group mechanism, neighboring group participation by p and s bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl systems, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations. The SN1 mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.
Book Suggested

9. Pericyclic Reactions, S.M. Mukherji, Macmillan, India
SEMESTER –I
Paper-III
MCH-403: PHYSICAL CHEMISTRY I

Unit-I
Introduction to Exact Quantum Mechanical Results
Schrödinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrödinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom and helium atom.

Unit-II
Approximate Methods
The variation theorem, linear variation principle. Perturbation theory (First order and nondegenerate). Applications of variation method and perturbation theory to the Helium atom.

Molecular Orbital Theory
Huckel theory of conjugated systems bond and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical cyclobutadiene etc. Introduction to extended Huckel theory.

Unit-III
Angular Momentum
Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum operator using ladder operators addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

Unit-IV
Classical Thermodynamics

Unit-V
Statistical Thermodynamics
Books Suggested

1. Physical Chemistry, P.W. Atkins, ELBS.
4. Coulson’s Valence, R. McWeeny, ELBS.
SEMESTER– I
Paper-IV
MCH-404: Group Theory, Mathematics for Chemists and Biology for Chemists

Unit-I
Symmetry and Group theory in Chemistry
Symmetry elements and symmetry operation, definition of group, subgroup. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices (representation for the Cn, Cnv, Cnh, Dnh group to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy. Derivation of character table for C2v and C3v point group Symmetry aspects of molecular vibrations of H2O molecule.

Unit-II
Vectors
Vectors, dot, cross and triple products etc. gradient, divergence and curl, Vector Calculus.

Matrix Algebra
Addition and multiplication; inverse, adjoint and transpose of matrices.

Or
Carbohydrates

Unit-III
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.).

Or
Amino-acids, Peptides and Proteins
Unit-IV
Integral calculus
Basic rules for integration, integration by parts, partial fractions and substitution. Reduction formulae, applications of integral calculus. Functions of several variables, partial differentiation, co-ordinate transformations (e.g. Cartesian to spherical polar). First-order and first degree differential equations, Applications to chemical kinetics,

Or

Lipid

Unit –V
Permutation and Probability
Permutations and combinations, probability and probability theorems average, variance root means square deviation examples from the kinetic theory of gases etc., fitting (including least squares fit etc with a general polynomial fit.

Or

Nucleic Acids
Purine and pyrimidine bases of nucleic acids, base pairing via H bounding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acid (DNA), double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The chemical basis for heredity, an overview of replication of DNA, transcription, translation and genetic code. Chemical synthesis of mono and trinucleoside.

Books suggested
3. The chemistry Mathematics Book, E.Steiner, Oxford University Press.
SEMESTER –II
Paper-V
MCH-405: INORGANIC CHEMISTRY II

Unit-I
Electronic Spectral Studies of Transition Metal Complexes:
Spectroscopic ground states, correlation. Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), Selection rule for electronic spectroscopy. Intensity of various type electronic transitions, Calculations of 10Dq, B and β parameters, charge transfer spectra.

Unit-II
Magnetic Properties of Transition Metal Complexes
Anomalous magnetic moments, Quenching of Orbital contribution. Orbital contribution to magnetic moment, magnetic exchange coupling and spin crossover.

Unit-III
Metal π-Complexes
Metal carbonyl, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding structure and important reaction of transition metal nitrosyl, dinitrogen and dioxgen complexes; tertiary phosphone as ligand.

Unit-IV
Metal Clusters
Higher boranes, carboranes, metalloboranes and metallo-carboranes compounds with metal metal multiple bonds.

Unit-V
Optical Rotatory Dispersion and Circular Dichroism
Linearly and circularly polarized lights; optical rotatory power and circular birefringence, ellipticity and circular dichroism; ORD and Cotton effect, Faraday and Kerr effects; Assignment of electronic transitions; applications of ORD and CD for the determination of (i) absolute configuration of complexes and (ii) isomerism due to non-planarity of chelate rings.

Books Suggested:
SEMESTER –II
Paper-VI
MCH-406: ORGANIC CHEMISTRY II

Unit-I
Aromatic Electrophilic Substitution
The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gatterman-Koch reaction

Aromatic Nucleophilic Substitution
The SNAr, SN1, benzyne and SN2 mechanism, Reactivity effect of substrate structure, leaving group and attacking nucleophile. The Von Richte, Sommelet-Hauser, and Smiles rearrangements.

Unit-II
Free Radical Reactions
types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, autooxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

Unit III
Addition Reactions
Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio-and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bounds, hydrogenation of aromatic rings. Hydroboration, Michael reaction, sharpless asymmetric epoxidation.

Unit-IV
Addition to Carbon-Hetero Multiple bonds
Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acid esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Witting reaction. Mechanism of condensation reactions involving enolates-Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

Elimination Reactions
The E2, E1 and E1 cB mechanisms and their spectrum. Orientation of the double bond. Reactivity-effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.
Unit-V
Pericyclic Reactions
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. Electrocyclic reactions-conrotatory and disrotatory motions, 4n 4n+2 and allyl systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, sigmatropic involving carbon moieties, 3,3- and 5,5 sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Book Suggested
SEMESTER–II
Paper-VII
MCH-407: PHYSICAL CHEMISTRY II

Unit-I
Chemical Dynamics
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 (hydrogenbromine and hydrogen-chlorine reactions) and homogenous catalysis, kinetics of enzyme reactions, general features for fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis ad the nuclear magnetic resonance method, dynamics of unimolecular reactions (Lindemann Hinshelwood and Rice-Ramsperger-Kassel- Marcus (RRKM) theories for unimolecular reactions).

Unit-II
Surface Chemistry
Adsorption
Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), Surface films on liquids (Electro-kinetic phenomenon).

Micelles
Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

Unit-III
Macromolecules
Polymer-definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization. Molecular mass, number and mass average molecular mass, molecular mass determination (Osmometry, viscometry, diffusion and light scattering methods), sedimentation, chain configuration of macromolecules, calculation of average dimension of various chain structures.

Unit-IV
Non Equilibrium Theromodynamics
Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion, electric conduction.
**Unit-V**  
**Electrochemistry**


**Books Suggested**

1. Physical Chemistry, P.W. Atkins, ELBS.
4. Coulson's Valence, R. Mc Weeny, ELBS.
SEMESTER – II
Paper-VIII
MCH-408: Spectroscopy II and Diffraction Methods

Unit-I
Nuclear Magnetic Resonance Spectroscopy
Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors, influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant "j" Classification (AXB, AMX, ABC, A2B2 etc.). spin decoupling; basic ideas about instrument, NMR studies of nuclei other than protin-13C, 19F and 31P. FT NMR, advantages of FT NMR.

Unit II
Nuclear Quadrupole Resonance Spectroscopy
Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splitting. Applications.

Unit-III
Electron Spin Resonance Spectroscopy
Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and Mc Connell relationship, measurement techniques, applications.

Unit-IV
X-ray Diffraction

Unit-V
Electron Diffraction
Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

Neutron Diffraction
Scattering of neutrons by solids measurement techniques, Elucidation of structure of magnetically ordered unit cells.

Books suggested
PRACTICAL
(Duration: 6-8 hrs in each branch)

Practical examination shall be conducted separately for each branch in Second semester (M.Sc. 1st Year)

Inorganic Chemistry

Separation and estimation of two metal ions. 35
Preparation and synthesis of metal complexes 20
Paper chromatography 20
Record 10
Viva Voce 15
Total 100

1. Separation and estimation of two metal ions:
   (i) Estimation of copper and nickel both by gravimetric method.
   (ii) Estimation of barium gravetrically and copper volumetrically methods.
   (iii) Estimation of copper and zinc in a mixed solution of both by gravimetric methods.
   (iv) Estimation of nickel and zinc in a mixed solution of both by gravimetric methods.

2. Preparation and synthesis of metal complexes
   (i) VO(acac)₂
   (ii) Ni(acac)₂
   (iii) K₃[Fe(C₂O₄)₃]
   (iv) Prussian Blue, Turnbull’s Blue.
   (v) Co(NH₃)₆[Co(NO₂)₆]
   (vi) Hg[Co(SCN)₄]
   (vii) [Cu(NH₃)₄]SO₄·H₂O
   (viii) [Ni(NH₃)₆]Cl₂
   (ix) Ni(dmg)₂

3. Paper chromatography:
   Separation of cations by Paper Chromatography of following cations:
   (i) Ag(I), Pb(II) and Hg₂(II)
   (ii) Hg(II), Cu(II) and Pb(II)
   (iii) Ni(II), Co(II) and Zn(II)
   (iv) Ni(II), Co(II) and Cu(II)
Physical Chemistry

Chemical Kinetics (determination of rate constant for hydrolysis of esters) 35
Determination of composition of a mixture of weak and strong acids by conductometric titration 20
Determination of composition of a mixture of weak and strong acids by pH metric titration 20
Record 10
Viva Voce 15
Total 100

1. Chemical Kinetics

(i) Determination of velocity constant of the hydrolysis of methyl acetate catalysed by an acid (say HCl, H₂SO₄, etc.).
(ii) Determination of velocity constant of saponification of ethyl acetate with sodium hydroxide.
(iii) Determination of velocity of the reaction between potassium persulphate and potassium iodide.

2. Determination of composition of a mixture of weak and strong acids by conductor metric titration of following acids:

   (i) HCl and CH₃COOH
   (ii) HNO₃ and CH₃COOH
   (iii) H₂SO₄ and CH₃COOH

3. Determination of composition of a mixture of weak and strong acids by pH metric titration of followings acids:

   (i) HCl and CH₃COOH
   (ii) HNO₃ and CH₃COOH
   (iii) H₂SO₄ and CH₃COOH
Organic Chemistry

<table>
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<th>Qualitative Analysis</th>
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<td>Organic Synthesis</td>
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<tr>
<td>Quantitative analysis</td>
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<tr>
<td>Viva Voce</td>
<td>15</td>
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<tr>
<td>Total</td>
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1. **Qualitative Analysis**
   Separation, purification and identification of compounds of ternary mixture (one liquid and one solid) using TLC and columns chromatography, chemical tests. IR spectra to be used for functional group identification.

2. **Organic Synthesis**
   - Acetylation: Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.
   - Oxidation: Adipic acid by chromic acid oxidation of cyclohexanone.
   - Grignard reaction: Synthesis of triphenylmethanol from benzoic acid.
   - Aromatic electrophilic substitutions: Synthesis of p-nitroaniline and p-bromoaniline.
   - Aldol condensation: Dibenzal acetone from benzaldehyde.
   - Synthesis of different Schiff bases using salicylaldehyde and amines.
   - Synthesis of different dithiocarbamates. The products may be characterized by Spectral Techniques.

3. **Quantitative Analysis**
   Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method. Estimation of amines/phenols using bromate bromide solution/or acetylation method. Determination of iodine and Saponification values of an oil sample. Determination of DO, COD and BOD of water sample.

Books Suggested

5. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold.
10. Advanced Physical Chemistry by Gurtu and Gurtu, Pragati Prakashan.
SEMESTER –III
Paper-I
MCH-501: APPLICATION OF SPECTROSCOPY - I

Unit - I
Electronic Spectroscopy:
Electronic Spectral Studies for d^1- d^9 systems in octahedral, tetrahedral and square planer complexes,

Unit - II
Vibrational Spectroscopy
Symmetry and shapes of AB₂, AB₃, AB₄, AB₅ and AB₆, mode of bonding of ambidentate ligands, nitrosyl, ethylenediamine and diketonato complexes, application of resonance Raman spectroscopy and its applications.

Unit -III
Nuclear Magnetic Resonance Spectroscopy – I
General introduction and definition, Chemical shift, spin – spin interaction, shielding and deshilding mechanism, mechanism of measurement of chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, and amides & mercapto).

Unit-IV
Nuclear Magnetic Resonance Spectroscopy – II
Chemical exchange, effect of deuteration, Complex spin – spin interation between two, three, four and five nuclei (1 order spectra) Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with disordered angle, NMR shift reagents, solvent effects, Nuclear overhauser effect (NOE).

Unit-V
Mössbauer Spectroscopy
Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{2+} and Fe^{3+} compounds including those of intermediate spin, (2) Sn^{2+} and Sn^{4+} compounds nature of M-L bond, coordination number, structure and (3) detection of oxidation state and in equivalent MB atoms.

Book Suggested
7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, .V. Parish, Ellis Haywood.
SEMESTER –III
Paper II
MCH-502: PHOTOCHEMISTRY

Unit-I
Photochemical Reactions
Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

Unit -II
Determination of Reaction Mechanism
Classification, rate constants and life times of reactive energy state determination of rate constants of reactions, Effect of light intensity on the rate of photochemical reactions, Types of photochemical reactions-photo dissociation, gas-phase photolysis.

Unit -III
Photocatalysis of Alkenes
Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes.

Photocatalysis of Aromatic Compounds
Isomerisations, additions and substitutions.

Unit -IV
Photocatalysis of Carbonyl Compounds
Intramolecular reactions of carbonyl compounds-saturated, cyclic and acyclic, α, β, γ unsaturated and α, β, unsaturated compounds, cyclohexadienones, Intermolecular cycloaddition reactions-dimerisations and oxetane formation.

Unit-V
Miscellaneous Photocatalysis Reactions.
Photo-Fries reactions of annelids, Photo-Fries rearrangement, Barton reaction, Singlet molecular oxygen and its reactions, Photochemical formation of smog,Photodegradation of polymers, Photochemistry of vision.

Books Suggested
SEMESTER –III
Paper III
MCH-503: Polymer Chemistry

Unit-I
Basics

Unit-II
Polymer Characterization

Unit-III
Analysis and testing of polymers

Unit-IV
Inorganic Polymers
A general survey and scope of Inorganic Polymers: special characteristics, classification, homo and hetero atomic polymers. Structure, Properties and Applications of
   a. Polymers based on boron-borazines, boranes and carboranes.
   b. Polymers based on Silicon, silicone’s polymetalloxanes and polymetallosiloxanes, silazanes.

Unit V
Structure, Properties and Application of
   a. Polymers based on Phosphorous-Phosphazenes, Polyphosphates
   b. Polymers based on Sulphure-Tetrasulphur tetranitride and related compounds.
   c. Co-ordination and metal chelate polymers.

Books Suggested
5. Inorganic Rings and Cages : D.A. Armitage.
SEMESTER –III
Paper IV
MCH-504: Heterocyclic Chemistry

Unit-I
Nomenclature of Heterocycles
Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic fused and bridged heterocycles.

Aromatic Heterocycles
General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in 1H NMR spectra. Empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations). Heteroaromatic reactivity and tautomerism in aromatic heterocycles.

Unit-II
Non-aromatic Heterocycles

Unit-III
Small Ring Heterocycles
Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes.

Benzo-Fused Five-Membered Heterocycles
Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes.

Unit-IV
Meso-ionic Heterocycles
General classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications.

Six-Membered Heterocycles with one Heteroatom
Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and phridones. Synthesis and reactions of quionlizinium and benzopyrylium salts, coumarins and chromones.

Unit-V
Six Membered Heterocycles with Two or More Heteroatoms
Synthesis and reactions of diazones, triazines, tetrazines and thiazines. Seven-and Large-Membered Heterocycles
Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines.
Heterocyclic Systems Containing P, As, Sb and B
Heterocyclic rings containing phosphorus: Introduction, nomenclature, synthesis and characteristics of 5- and 6-membered ring systems phosphorinaes, phosphorines, phospholanes and phospholes. Heterocyclic rings containing As and Sb: Introduction, synthesis and characteristics of 5- and 6-membered ring system. Heterocyclic rings containing B: Introduction, synthesis reactivity and spectral characteristics of 3-5- and 6-membered ring system.

Books Suggested:
2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
SEMESTER – IV
Paper V
MCH-505: APPLICATION OF SPECTROSCOPY

Unit-I

Ultraviolet and Visible spectroscopy
Various electronic transitions (185-800 nm) Beer-Lambert law, 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 compounds. Steric effect in biphenyls.

Unit-II

Infrared Spectroscopy
Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ether’s, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketone’s, aldehyde’s, esters, amides, acids, anhydride’s, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and fermi resonance.

Unit-III

Nuclear Magnetic Resonance of Paramagnetic Substances in Solution
The contact and Pseudo contact shifts, factors affecting nuclear relaxation, some applications including biochemical systems, an overview of NMR of metal nuclide with emphasis on $^{195}$Pt and $^{119}$Sn NMR.

Unit-IV

Carbon-13 NMR Spectroscopy
General considerations, chemical shift (aliphatic olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two dimension NMR spectroscopy-COSY, NOESY, DEPT, HMBC and HMQC techniques.

Unit V

Mass Spectrometry
**Book Suggested**

7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, V. Parish, Ellis Haywood.
SEMESTER –IV  
Paper-VI  
MCH-506: SOLID STATE CHEMISTRY

Unit-I  
**Solid State Reactions**  
General principles, experimental procedure, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

Unit-II  
**Crystal Defects and Non-Stoichiometry**  
Perfect and imperfect crystals, intrinsic and extrinsic defects-point defects, line and plane defects, vacancies-Schottky detects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry defects.

Unit-III  
**Electronic Properties and Band Theory**  

Unit-IV  
**Organic Solids**  
Electrically conducting solids. organic charge transfer complex, organic metals, new superconductors.

Unit-V  
**Liquid Crystals:**  
Types of liquid crystals: Nematic, Smectic, Ferroelectric, Antiferroelectric, Various theories of LC, Liquid crystal display, New materials.

Books Suggested.  
SEMESTER -IV  
Paper VII  
MCH-507: Chemistry of Natural Products

Unit-I  
**Terpenoids and Carotenoids**  
Calcifications, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol α-Terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-Carotene.

Unit-II  
**Alkaloids**  
Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, (+)-Coniine, Nicotine, Atropine, Quinine and Morphine.

Unit-III  
**Steroids**  
Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, Isolation, Structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone, Aldosterone, Biosynthesis of Steroids.

Unit-IV  
**Plant Pigments**  
Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Luteolin Quercetin, Myrcetin, Quercetin 3-glucoside, Vitexin, Diadzein, Aureusin, Cyanidin-7-arabinoside, Cyanidin, Hirsutidin, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

**Prophyrins**  
Structure and synthesis of Haemoglobin and Chlorophyll.

Unit V  
**Prostaglandins**  
Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE2 and PGF2a.

**Pyrethroids and Rotenones**  
Synthesis and reactions of Pyrethroids and Rotenones. (For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible).

**Books Suggested**

1. Natural Products : Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope adn J.B. Harbome, Longman, Esses.
2. Organic Chemistry : Vol. 2 1L. Finar, ELBS
SEMESTER – IV
PAPERS IV (OPTIONAL)

Out of the following select any one paper each of marks 100 (75 + 25)

OPT – MCH−508 Organic Synthesis
OPT – MCH−509 Organotransition Metal Chemistry
OPT – MCH−510 Analytical Chemistry
OPT – MCH−511 Electrochemistry
OPT – MCH−512 Medicinal Chemistry
SEMESTER –IV
Optional–1
MCH-508: Organic Synthesis

Unit-I
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 and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reaction, amine synthesis, Protection of groups, chemo region and stereo selectivity.

Unit-II
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, a-b- unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Micheal addition and Robinson annelation.

Unit-III
Oxidation
Introduction, Different oxidative processes. Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated and unactivated) Alcohols, diols, aldehyde’s, ketones, ketals and carboxylic acids, amines, hydrazines, and sulphides. Oxidations with ruthenium tetraoxide, iodobenzene diacetate and thallium. (III) Nitrate.

Reduction

Unit IV
Organometallic Reagents
Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details. Group I and II metal organic compounds Li, Mg, Hg, Cd, Zn and Ce Compounds.

Unit V
Synthesis of some complex molecules:
Application of the above in the synthesis of following compounds: Canphor, longifoline, cartisone, reserpine, vitamin D, juvabion, aphidicolin and fredericamycin. A

Books Suggested
SEMESTER –III
Optional–2
MCH-509: Organotransition Metal Chemistry

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

Unit -II
Transition Metal π-Complexes
Transition metal π-Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

Unit -III
Transition organometalic compounds:
Transition metal compounds with bonds to hydrogen, boron, silicon

Unit -IV
Homogeneous Catalysis
Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxoreaction), explanation reactions, activation of C-H bond.

Unit -V
Fluxional Organometallic Compounds
Flexionality and dynamic equilibrium in compounds such as η² olefine, η³-allyl and dienyl complexes.

Books Suggested
SEMESTER –IV
Optional–3
MCH-510: Analytical Chemistry

Unit-I
Introduction

Errors and Evaluation
Definition of terms in mean and median. Precision-standard deviation, relative standard deviation. Accuracy-absolute error, relative error. Types of error in experimental data determinate (systematic), indeterminate (or random) and gross. Sources of error and the effects upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data-indeterminate errors. The uses of statistics.

Unit-II
Food analysis

Unit-III
Analysis of Water Pollution

Unit-IV
Analysis of soil, Fuel, Body Fluids and Drugs
(a) Analysis of Soil, moisture pH total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts.
Unit-V

(a) **Clinical Chemistry**: Composition of blood-collection and preservation of samples. Clinical analysis. Serum electrolytes, blood glucose, blood urea nitrogen, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphates. Immunoassay: principles of radio immunoassay (RIA) and applications. The blood gas analysis trace elements in the body.

(b) **Drug analysis**: Narcotics and dangerous drug. Classification of drugs. Screening by gas and thin-layer chromatography and spectrophotometric measurements.

**Book Suggested**

6. Principles of Instrumental Analysis D.A. Skoog W.B. Saunders.
SEMESTER –IV
Optional–4
MCH-511: Electrochemistry

Unit-I
Electrochemical Generators (Fuel Cells): Hydrogen oxygen cells, Hydrogen Air cell, Hydrocarbon air cell, Alkane fuel cell, Phosphoric and fuel cell, direct NaOH fuel cells, applications of fuel cells.

Electrochemical Energy Storage:

Unit-II
Corrosion and Stability of Metals:

Inhibiting Corrosion:
Cathodic and Anodic Protection. (i) Inhibition by addition of substrates to the electrolyte environment, (ii) by charging the corroding method from external source, anodic Protection, Organic inhibitors, The fuller Story Green inhibitors.


Unit-III
Bioelectrochemistry:
bioelectrodics, Membrane Potentials, Simplistic theory, Modern theory, Electrical conductance in biological organism: Electronic, Protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

Kinetic of Electrode Process:
Essentials of Electrode reaction. Current Density, Overpotential, Tafel Equation, Butler Volmer equation. Standard rate constant (K) and Transfer coefficient (a), Exchange Current.
Irreversible Electrode processes: Criteria of irreversibility, informatino from irreversible wave.

Unit-IV
Methods of determining kinetic parameters for quasi-reversible and irreversible waves: Koutecky’s methods, Meits Israel Method, Gellings method.
Electrocatalysis:

Unit-V
Potential Sweep Method:
Linear sweep Voltammetry, Cyclic Voltammetry, theory and applications. Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode techniques: comparison with controlled potentials methods, chronopotentiometry, theory and applications.

Bulk Electrolysis Methods:
Controlled potential coulometry, Controlled Coulometry, Electroorganic synthesis and its important applications. Stripping analysis: anodic and Cathodic modes, Pre electrolysis and Stripping steps, applications of Stripping Analysis.

Books Suggested
8. Topics in pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India)
SEMESTER – IV
Optional – 5
MCH-512: Medicinal Chemistry

Unit-I
Structure and activity:

Unit-II
Pharmacodynamics:
Introduction, elementary treatment of enzymes stimulation, enzyme inhibition, sulfonamides, membrane active drugs, drug metabolism, xenobiotics, biotransformation, significance of drug metabolism in medicinal chemistry.

Unit-III
Antibiotics and antibacterials:
Introduction, Antibiotic β-Lactam type - Penicillins, Cephalosporins, Antitubercular. Streptomycin, Broad spectrum antibiotics. Tetracyclines, Anticancer – Dactinomycin (Actinomycin D)

Unit-IV
Antifungal
Polyenes, Antibacterial - Ciprofloxacin, Norfloxacin, Antiviral. Acyclovir
Antimalariais: Chemotherapy of malaria. SAR. Chloroquine, Chloroguanide and Mefloquine

Unit-V
Non-steroidal Anti-inflammatory Drugs:
Diclofenac Sodium, Ibuprofen and Netopam
Antihistaminic and antiasthmatic agents:
Terfenadine, Cinnarizine, Salbutamol and Beclomethasone dipropionate.

Books Suggested:
1. Introduction to medicinal chemistry, A. Gringuage, Wiley-VCH.
5. Goodman and Gilman’s Pharmacological Basis of Therapeutics, Mc-GRaw- Hill.
PRACTICAL
(Duration: 6-8 hrs in each branch)

Practical examination shall be conducted separately for each branch in Second semester (M.Sc. 2\textsuperscript{nd} Year)

Inorganic Chemistry

<table>
<thead>
<tr>
<th>Activity</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative determinations of a three component mixture</td>
<td>35</td>
</tr>
<tr>
<td>Synthesis and characterization of metal complexes</td>
<td>20</td>
</tr>
<tr>
<td>Chromatography Separations</td>
<td>20</td>
</tr>
<tr>
<td>Record</td>
<td>10</td>
</tr>
<tr>
<td>Viva Voce</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

1. Quantitative determinations of a three component mixture:
   One Volumetrically and two gravimetrically

   (i) Cu\textsuperscript{2+}, Ni\textsuperscript{2+}, Zn\textsuperscript{2+}
   (ii) Cu\textsuperscript{2+}, Ni\textsuperscript{2+}, Ag\textsuperscript{2+}
   (iii) Cu\textsuperscript{2+}, Ni\textsuperscript{2+}, Ba\textsuperscript{2+}

2. Synthesis and characterization of following metal complexes:

   (i) Sodium tetrathionate Na\textsubscript{2}S\textsubscript{4}O\textsubscript{6}.
   (ii) Metal complex of dimethyl sulfoxide : CuCl\textsubscript{2}.2DMSO
   (iii) Synthesis of metal acetylacetonate
   (iv) Synthesis of copper and nickel Schiff base complexes.
   (v) Synthesis of copper and nickel dithiocarbamates

3. Chromatographic Separations

   (i) Cadmium and zinc
   (ii) Zinc and magnesium.
   (iii) Thin-layer / Paper chromatography-separation of nickel, manganese, cobalt and zinc. Determination of R\textsubscript{f} values.
Physical Chemistry

Chemical Kinetics (determination of strength of two acids) 35
Determination of Equivalence conductance of strong electrolyte and polarography 20
Spectroscopy and study of adsorption 20
Record 10
Viva Voce 15
Total 100

1. Chemical Kinetics (determination of strength of two acids)
   (i) Determination of relative strengths of HCl and H₂SO₄ (k₁ / k₂) for the hydrolysis of methyl acetate.
   (ii) Determination of relative strengths of HNO₃ and H₂SO₄ (k₁ / k₂) for the hydrolysis of methyl acetate.

2. Determination of Equivalence conductance of following strong electrolyte:
   (a) Equivalence conductance
      (i) KCl
      (ii) NaCl
      (iii) AgNO₃
      (iv) HCl
      (v) KNO₃
   (b) Polarography
      i. Identification and estimation of metal ions such as Cd²⁺, Pb²⁺, Zn²⁺, and i²⁺ etc. polarographically.
      ii. Study of a metal ligand complex polarographically (using Lingane’s Method).

3. Spectroscopy and adsorption
   (a) Spectroscopy
      i. Determination of pKa of an indicator (e.g. methyl red) in (a) aqueous and (b) micellar media.
      ii. Determination of stoichiometry and stability constant of Ferric isothiocyanate ion complex ion in solution.
   (b) Adsorption
      To study the adsorption of oxalic acid on activated charcoal and test the validity of Freundlich’s adsorption isotherm.
Organic Chemistry

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Multistep of organic compounds</td>
<td>35</td>
</tr>
<tr>
<td>Isolation</td>
<td>20</td>
</tr>
<tr>
<td>Paper Chromatography</td>
<td>20</td>
</tr>
<tr>
<td>Record</td>
<td>10</td>
</tr>
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<td>Viva Voce</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

1. **Multi-step Synthesis of Organic Compounds**

2. **Isolation**
   1. Isolation of caffeine from tea leaves.
   2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).
   3. Isolation of lactose from milk (purity of sugar should be checked by LC and PC and Rf values reported).
   4. Isolation of nicotine dipicrate from tobacco.
   5. Isolation of piperine from black pepper.
   6. Isolation of lycopene from tomatoes.
   7. Isolation of b-carotene from carrots.
   8. Isolation of eugenol from clove.
   9. Isolation of (+) limonine from citrus rind.

3. **Paper Chromatography**
   Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Books Suggested

1. Inorganic Experiments, J. Derek Woolings, VCH.
6. Findley’s Practical Physical chemistry, B.P. Levitt, Longman.
7. Advanced Physical Chemistry by Gurtu and Gurtu, Pragati Prakashan.