JANNAYAK CHANDRASHEKHAR UNIVERSITY BALLIA

B.Sc. (Chemistry) Syllabus

Year	Paper	Paper Title	Maximum mark
B.Sc. 1	I	Inorganic Chemistry	100
	II	Organic Chemistry	100
	III	Physical Chemistry	100
B.Sc. 2	I	Inorganic Chemistry	100
	II	Organic Chemistry	100
	III	Physical Chemistry	100
B.Sc. 3	I	Inorganic Chemistry	100
	II	Organic Chemistry	100
	III	Physical Chemistry	100

Marks Distribution

Theory:

All papers of 100 maximum marks each with the following distribution

- Internal Assessment 20 marks
- Theory Examination 80 Marks

Practical

Practical in all three years of 100 marks each. Distribution is as follows

- Inorganic Chemistry Exercise
27 marks
- Organic Chemistry Exercise
27 marks

Physical Chemistry Exercise 26 marks

- Practical Record 10 marks
- Viva 10 marks

B.Sc. I Paper- I

Inorganic Chemistry Maximum Marks -100 (External 80+ Internal 20)

Learning of Objectives: To give basic knowledge of atoms and molecules

UNIT – I

I. Atomic Structure

Idea of de Broglie matter waves, Heisenberg uncertainity principle, atomic orbitals, Schrödinger wave equation, significance of Ψ and Ψ^2, quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configurations of the elements, effective nuclear charge (The Slater's rule).

II. Periodic Properties

Atomic and ionic radii, ionization energy, electron affinity and electronegativity- definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

UNIT II

III. Chemical Bonding

(A) Covalent bond: valence bond theory and its limitations, directional characteristic of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions. Valence Shell Electron Pair Repulsion (VSEPR) theory to NH_3, H_3O^+, SF_4, ClF_3, ICl_2^- and H_2O. Molecular Orbital theory for homonuclear and heteronuclear (CO, NO, CN^- and NO^+) diatomic molecules. Bond strength and the bond energy, percentage ionic character from dipole moment and electronegativity difference.

(B) Ionic solid: ionic structures, radius ratio effect and coordination number, limitation of ratio rule, Lattice defects, semiconductors, Lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarizability of ions. Fajan's rule.

(C) Weak interactions: hydrogen bonding, van der Waals forces.

UNIT III

IV. s-Block Elements

Comparative study, diagonal relationships, salient features of hydrides, salvation and complexation tendencies including their function in Biosystems. An introduction to alkyls and aryls.

V. Chemistry of Noble Gases

Chemical properties of the noble gases. Chemistry of xenon, structure and bonding of fluorides, oxides and oxyfluorides of xenon.

UNIT IV

VI. p-Block Elements

Comparative study (including diagonal relationship) of group 13-17 elements. Compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazines, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetranitride, basic properties of halogens, interhalogens and polyhalides.

Internal Assessment:

B.Sc. I Paper-I

Inorganic Chemistry

Text Books (Theory Courses):

(a) Concise Inorganic Chemistry, J.D. Lee, Blackwell Science Ltd.
(b) Inorganic Chemistry, Puri, Sharma, Kalia and Kaushal.
(c) Pradeep's Inorganic Chemistry, K.K. Bhasin, Pradeep Publication.
(d) Chemistry for degree students, R. L. Madan

Reference Books:

(a) Inorganic Chemistry, J.E.Huheey, Ellen A. Keiter, Richard L. Keiter, Addison Wesley Longman (Singapore) Pvt. Ltd.
(b) Inorganic Chemistry, D.E.Shriver, P W. Atkins and C.H.L. Langford, Oxford.
(c) Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson and P.L. Gaus, Wiley.
(d) Concepts of Models of Inorganic Chemistry, B. Douglas, D. McDaniel and J Alexander, John Wiley.
(e) Inorganic Chemistry, W.W. Porterfield, Addison - Wesley.
(f) Inorganic Chemistry, A.G. Sharpe, ELBS
(g) Inorganic Chemistry, G.L. Meissler and D.A. Tarr, Prentice-Hall.

B.Sc. I Paper -II

Organic Chemistry

Maximum mark -100 (External 80 + Internal 20)

Learning Objectives: The purpose of study of organic chemistry is to know about the different organic compounds from which all living things are made up of. How they may be prepared and synthesized. By knowing about different organic compounds we can synthesize a wide variety of compounds which are not naturally found but they are very important for us.

Unit – I

I Structure and Bonding

Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bon, van der Waals interactions, inclusion compounds, clatherates, charge transfer complexes, resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.

II Mechanism of Organic Reactions

Curved arrow notation, drawing electron movements with allows, half-headed and double-headed arrows, hemolytic and heterolytic bond breaking. Types of reagents – electrophiles and nucleophiles, Types of organic reactions, Energy considerations.

Reactive intermediates – Carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning format charges on intermediates and other ionic species.

Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).

III Alkanes and Cycloalkanes

IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atom in alkanes, Isomerism in alkanes, sources methods of formation (with special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids), physical properties and chemical reactions of alkanes.

Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.

Cycloalkanes – nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strain less rings. The case of cyclopropane ring, banana bonds.

cyclopropane ring, banana bonds.

Unit – II

IV Stereochemistry of Organic Compounds

Concept of isomerism. Types of isomerism.

Optical isomerism – elements of symmetry, molecular chirality, enantionmers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and recemization.

Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclaute.

Geometric isomerism – determination of configuration of geometric isomers. E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.

Conformational isomerism -- conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives. Newman projection and Sawhorse formulae, Fischer and flying wedge formulae.

Difference between configuration and conformation.

Unit – III

V Alkenes, Cycloalkenes, Dienes and Alkynes

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration. The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes.

Chemical reactions of alkenes – mechanism involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$. Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene.

Methods of formation, conformation and chemical reactions of cycloalkenes.

Nomenclature and classification of dienes: isolated, conjugated and cumulated dienes. Structure of allenes and butadiene, methods of formation, polymerization, Chemical reaction – 1,2 and 1,4 additions, Diets-Alder reaction.

Nomenclature, structure and bonding in alkynes. Methods of formation. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization.

Unit – IV

VI Arenes and Aromaticity

Nomenclature of benzene derivatives. The aryl group. Aromatic nucleus and side chain. Structure of benzene: molecular formula and kekule structure. Stability and carbon-carbon bond lengths of benzene, resonance structure, MO picture.

Aromaticity: the Huckel rule, aromatic ions.

Aromatic electrophilic substitution – general pattern of the mechanism, role of σ and π complexes. Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel-Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio. Side chain reactions of benzene derivatives. Birch reduction.

Methods of formation and chemical reactions of alhylbenzenes, alkynylbenzenes and biphenyl.

VII Alkyl and Aryl Halides

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions. Mechanisms of nucleophilic substitution reactions of alkyl halides, S_N2 and S_N1 reactions with energy profile diagrams.

Polyhalogen compounds: chloroform, carbon tetrachloride.

Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions.

Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides. Synthesis and uses of DDT and BHC.

Internal Assessment

Text Books (Theory Courses):

a. Organic Chemistry, Vol. I, I.L. Finar, Pearson Education.
b. Organic Chemistry, M.K. Jain, Shoban Lal& Co.
c. Pradeep's Organic Chemistry, S.N. Dhawan, Pradeep Publication.

Reference Books:

a. Organic Chemistry, Morrison and Boyd, Prentice Hall.
b. Organic Chemistry, L.G. Wade Jr. Prentice Hall.
c. Fundamentals of Organic Chemistry Solomons, John Wiley.
d. Organic Chemistry, Vol. I, II, III S.M. Mukherji, S.P. Singh and R.P. Kapoor, Wiley Eastern Ltd. (New Age International)
e. Organic Chemistry, F.A. Carey, McGraw-Hill Inc.
f. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.

B.Sc. I Paper -III

Physical chemistry

Maximum marks: 100 (External 80+ Internal 20)

Learning Objectives: To provide fundamental scientific principles in field of physical chemistry

UNIT- I

I. Mathematical Concepts and Computers

(A) Mathematical Concepts: Logarithmic relations, calculation of slopes, differentiation of simple functions like x, e^x, x^n, sin x, log x; maxima and minima, partial differentiation and reciprocity relations. Integration of some useful/relevant functions; permutations and combinations. Factorials, Probability.

(B) Computers: General introduction to computers, different components of a computer. Hardware and software, input-output devices, binary numbers and arithmetic; introduction to computer languages. Programming and operating systems.

UNIT-II

II. Gaseous State:

Postulates of kinetic theory of gases, Deviation of gases from ideal behaviour, van der Waals equation of State.

Critical phenomenon: PV isotherms of real gases, continuity of states, the isotherms of van der Waals equations, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of states.

Molecular Velocities: Qualitative discussion of the Maxwell's distribution of molecular velocities, collision numbers, mean free path and collision diameter. Liquification of gases (based on Joule Thomson effect).

III. Liquid State:

Intermolecular forces, structure of liquids (a qualitative description)
Structural differences between solids, liquids and gases.

Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic, smecticand cholesteric liquid crystals. Thermography and sevensegment cell.

Unit-III

IV. **Solid State**: Definition ofspace latticeandunit cell.
Laws of crystallography: (i) Law of constancy of interfacialangles (ii) Law of rationality of indices(iii) Symmetry elements in crystals and law of symmetry.

X-ray diffraction by crystals. Derivation of Bragg's equation. Determination of crystal structure of NaCl, KCl and CsCl(Laue's method and powder method).

V. **Colloidal State**
Definition of colloids, classification colloids.
Solids in liquids (sols): properties- Kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulz law, gold number.
Liquids in liquids(emulsions): types of emulsions, preparation. Emulsifier.
Liquids in solids (gels): Classification, preparation and properties, inhibition, general applications of colloids.

Unit-IV

VI. **Chemical Kinetics**: Rate of reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristics of simple chemical reactions- zero order, first order, second order, pseudo order reactions, half-life and mean life.Determination of the order of reaction- Differential method, method of integration, half-life method and isolation method.

Brief outlines of experimental methods of studying chemical kinetics: conductometric, potentiometric, optical methods, polarimetry and spectrophotometer.

Theories of chemical kinetics: Effect of temperature on the rate of reaction, Arrhenius equation,concept of activation energy.

Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).

Catalysis, characteristics of catalysed reactions,classification of catalysis, miscellaneous examples.

Internal Assessment:

Text Books (Theory Courses):

1. Physical Chemistry, Puri Sharma &Pathania.
2. Pradeep Physical Chemistry, Khetrapal, Pradeep Publication.
3. Computers and Common Sense, R. Hunt and Shelly, Prentice Hall.

Reference Books:

1. Physical Chemistry. G.M. Barrow. International Student Edition, McGrawHill
2. Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
3. The Elements of Physical Chemistry, P.W. Atkins, Oxford.
4. Physical Chemistry Through problems, S.K. Dogra and S. Dogra, Wiley Eastern Ltd.
5. Basic Programming with Application, V.K. Jain, Tata McGraw Hill.
6. Physical Chemistry, Glaston

B.Sc. I Practicals

180 Hrs (6 Hrs/week)

Inorganic Chemistry

Semimicro Analysis – cation analysis, separation and identification of ions from Groups I, II, III, IV, V and VI. Anion analysis.

Organic Chemistry

Laboratory techniques

Calibration of Thermometer

80-82° (Naphthalene),113.5-114° (Acetanilide),
132.5-133° (Urea), 100° (Distilled Water)

Determination of melting point

Naphthalene 80 -82°, Benzoic acid 121.5-122°
Urea 132.5-133°, Succinic acid 184.5-185°
Cinnamic acid 132.5-133°, Salicylic acid 157.5-158°
Acetanilide 113.5-114°, m-Dinitrobenzene 90°
p-Dichlorobenzene 52° Aspirin 135°

Determination of boiling points

Ethanol 78°, Cyclohexane 81.4°, Toluene 110.6°, Benzene 80°

Mixed melting point determination

Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)

Distillation

Simple distillation of ethanol-water mixture using water condenser
Distillation of nitrobenzene and aniline using air condenser

Crystallization

Concept of induction of crystallization
Phthalic acid from hot water (using fluted filter paper and stemless funnel)
Acetanilide from boiling water
Naphthalene from ethanol
Benzoic acid from water

Decolorisation and crystallization using charcoal

Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
Crystallization and decolorisation of impure naphthalene (100g of naphthalene mixed with 0.3 g of Congo Red using 1g decolorising carbon) from ethanol.

Sublimation (Simple and Vacuum)

Camphor, Naphthalene, Phthalic acid and Succinic acid.

Qualitative Analysis

Detection of extra elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and anilide) in simple organic compounds.

PHYSICAL CHEMISTRY

Chemical Kinetics

1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of ethyl acetate.
4. To study kinetically the reaction rate of decomposition of iodide by H_2O_2.

Distribution Law

1. To study the distribution of iodine between water and CCl_4.
2. To study the distribution of benzoic acid between benzene and water.

Colloids

1. To prepare arsenious sulphide sol and compare the precipitating power of mono-, bi- and trivalent anions.

Viscosity, Surface Tension

1. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentrations and calculate the excess viscosity of these solutions.
3. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl methyl ketone).

B.Sc. II Paper- I

Inorganic Chemistry

Maximum marks: 100(External 80 + Internal 20)

Learning Objectives: To study the properties of transition and inner transition elements and compound

UNIT I

I. Chemistry of Elements of First Transition Series

Characteristic properties of d-block elements.

Binary compounds (hydrides, halides and oxides) of the elements of the first transition series and complexes with respect to relative stability of their oxidation states, coordination number and geometry.

II. Chemistry of Elements of Second and Third Transition Series

General characteristics, comparative treatment of Zr/Hf, Nb/Ta , Mo/W in respect of ionic radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.

Unit - II

III. Coordination Compounds and double salts.

Werner's coordination theory and its experimental verification, Sidgwick's concept of effective atomic number, polydentate ligands or chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes, Limitations of VBT.

UNIT III

IV. Chemistry of Lanthanide Elements

Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.

V. Chemistry of Actinides

Electronic conformation, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.

Unit IV

VI. Oxidation and Reduction

Electrode potential, electrochemical series and its applications. Principles involved in the extraction of the elements.

VII. Acids and Bases

Arrhenius, Brønsted-Lowry, the Lux-Flood, solvent system and Lewis concept of acids and bases.

VIII. Non-aqueous Solvents

Physical properties of a solvent, types of solvents and their general characteristics, Reactions in non-aqueous solvents with reference to liquid NH_3 and liquid SO_2.

Internal Assessment:

B.Sc. II Paper-I

Inorganic Chemistry

Text Books (Theory Courses):

a. Concise Inorganic Chemistry, J.D. Lee, Blackwell Science Ltd.
b. Inorganic Chemistry, Puri, Sharma, Kalia and Kaushal.
c. Pradeep's Inorganic Chemistry, K.K. Bhasin, Pradeep Publication.
d. Chemistry for degree students, R. L. Madan

Reference Books:

a. Inorganic Chemistry, J.E.Huheey, Ellen A. Keiter, Richard L. Keiter, Addison Wesley Longman (Singapore) Pvt. Ltd.
b. Inorganic Chemistry, D.E.Shriver, P W. Atkins and C.H.L. Langford, Oxford.
c. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson and P.L. Gaus, Wiley.
d. Concepts of Models of Inorganic Chemistry, B.Douglas, D.McDaniel and J Alexander, John Wiley.
e. Inorganic Chemistry, W.W. Porterfield, Addison - Wesley.
f. Inorganic Chemistry, A.G. Sharpe, ELBS
g. Inorganic Chemistry, G.L. Meissler and D.A. Tarr, Prentice-Hall.

B.Sc. II Paper -II

Organic Chemistry Maximum marks 100 (External 80+ Internal 20)

Learning Objectives: The purpose of study of organic chemistry is to know about the different organic compounds from which all living things are made up of. How they may be prepared and synthesized. By knowing about different organic compounds we can synthesize a wide variety of compounds which are not naturally found but they are very important for us.

Unit I

I. **Electromagnetic Spectrum Absorption Spectra**:-

Ultraviolet (UV) absorption spectroscopy - absorption laws (Beer-Lambert law); molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome, Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. U.V. spectra of conjugated enes and enones.

Infrared (I.R.) absorption spectroscopy – molecular vibrations, Hooke's law, selection rules, intensity and position of I.R. bands, measurement of I.R. spectrum, fingerprint region, characteristic absorptions of various functional groups and interpretation of I.R. spectra of simple organic compounds.

Unit II

II. Alcohols:-

Classification and nomenclature.

Monohydric alcohols – nomenclature, methods of formation by reduction of aldehydes, Ketones, Carboxylic acids and Esters, Hydrogen bonding, Acidic nature, Reactions of alcohols.

Dihydric alcohols – nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacolo-pinacolone rearrangement.

Trihydric alcohols – nomenclature and methods of formation, chemical reactions of glycerol.

III. Phenols:-

Nomenclature, structure and bonding, Preparation of phenols, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols – electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Unit III

IV. Ethers and Epoxides:-

Nomenclature of ethers and methods of their formation, physical properties, Chemical reactions – cleavage and autoxidation, Ziesel's method.

Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

V. Aldehydes and Ketones:-

Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of alkedydes and ketones using 1,3-dithianes, synthesis of ketones from nitrites and from carboxylic acids. Physical properties.

Mechnism of nucleophillic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction.

Use of acetals as protecting group, Oxidation of aldehydes, Baeyer-Villiger oxidation of Ketones, Cannizzaro reaction, MPV, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable ketones.

An introduction to α,β unsaturated alkehydes and ketones.

Unit IV

VI. Carboxylic Acids:-

Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength. Preparation of carboxylic acids, Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction, Synthesis of acid chlorides, esters and amides. Reduction of carboxylic acids, Mechanism of decarboxylation.

Methods of formation and chemical reactions of halo acids, Hydroxy acids: malic, tartaric and citric acids.

Methods of formation and chemical reactions of unsaturated monocarboxylic acids.

Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.

VII. Carboxylic Acid Derivatives:-

Structure and nomenclature of acid chlorides, esters, amides(urea) and acid anhydrides.

Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution

Preparation of carboxylic acid derivatives, chemical reactions. Mechanisms of esterification and hydrolysis (acidic and basic)

VIII. Organic Compounds of Nitrogen:-

Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid.

Halonitroarenes: reactivity, Structure and nomenclature of amines, physical properties. Stereochemistry of amines. Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitrites), reductive amination of aldehydic and ketonic compounds. Gabriel-phthalimide reaction, Hofmann bromamide reaction. Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.

Internal Assessment:

Books Suggested (Theory Courses)

a. Organic Chemistry, Morrison and Boyd, Prentice Hall.
b. Organic Chemistry, L.G. Wade Jr. Prentice Hall
c. Fundamentals of Organic Chemistry Solomons, John Wiley.
d. Organic Chemistry, Vol. I, II, III, S.M. Mukherji, S.P. Singh and
a. R.P. Kapoor, Wiley Eastern Ltd. (New Age International).
e. Organic Chemistry, F.A. Carey, McGraw-Hill Inc.
f. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.
g. Organic Chemistry, Vol. I, II, I.L. Finar
h. Spectrometric Identification of organic compounds. Robert M.
b. Silverstein, Clayton G. Bassler, Terence C. Morril, John Wiley.

B.Sc.II Paper –III

Physical chemistry

Maximum marks: 100 (External 80+Internal 20)

Learning Objectives: To undrstand the dynamics of themodynamic system, production of energy that is released during reactions and phases of system

Unit I

(Thermodynamics & Chemical Equilibrium)

I. **Thermodynamics – I**

Definition of thermodynamic terms

System, surroundings etc. Types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process. Concept of heat and work.

First Law of Thermodynamics

Statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law – Joule-Thomson coefficient and inversion temperature. Calculation of w,q, dU&dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry

Standard state, standard enthalpy of formation – Hess's Law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.

I. **Chemical Equilibrium**

Thermodynamic derivation of law of mass action. Le Chatelier's principle.
Reaction isotherm and reaction isochore – Clapeyron-Clausius equation and its applications.

Unit II

III. **Thermodynamics – II**

Second law of thermodynamic

Need for the law, different statements of the law. Carnot's cycle and its efficiency, Carnot's theorem. Thermodynamic scale of temperature.

Concept of entropy

Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium.

Gibbs and Helmholtz functions

Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A &G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change. Variation of G and A with P, V and T. Relation between free energyand equilibrium constant.

Third law of thermodynamics:

Nernst heat theorem, statement and concept of residual entropy. Nernst distribution law –thermodynamic derivation, applications.

Unit III
(Electrochemistry – I &Phase Equlibrium)

IV. Electrochemistry – I

Electrical transport – conduction in metals and in electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution. Migration of ions and Kohlrausch's law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law its uses and limitations. Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf's method and moving boundary method.

Applications of conductivity measurements: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

V. Phase Equilibrium

Statement and meaning of the terms: phase, component and degree of freedom, derivation of Gibb's phase rule, phase equilibria of one component system – water, CO_2 and S systems.

Phase equilibria of two component system - solid liquid equilibria, simple eutectic – Bi-Cd, Pb-Ag systems, de-silverisation of lead.

Solid solutions: compound formation with congruent melting point (Mg-Zn) and incongruent melting point, ($FeCl_3$-H_2O) and ($CuSO_4$-H_2O) system

Unit IV
(Electrochemistry – II & Phase Equilibrium)

VI. Electrochemistry – II

Types of reversible electrodes: gas-metal ion, metal-ion, metal-insoluble salt-anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell E.M.F. and single electrode potential, standard hydrogen electrode, reference electrodes- standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells: reversible and irreversible cells, conventional representation of electrochemical cells.

EMF of a cell and its measurements. Computation of cell EMF.Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K)

Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a, determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods.

Buffers: mechanism of buffer action, Henderson-Hazel equation. Hydrolysis of salts.

Internal Assessment

Books Suggested (Theory Courses)

1. Physical Chemistry. G.M. Barrow. International Student Edition, McGraw Hill.
2. Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
3. The Elements of Physical Chemistry, P.W. Atkins, Oxford.
4. Physical Chemistry Through problems, S.K. Dogra and S. Dogra, Wiley Eastern Ltd.

B.Sc. II Practical

Inorganic Chemistry

Calibration of fractional weights, pipettes and burettes. Preparation of standard solutions. Dilution- 0.1 M to 0.001 M solutions.

Quantitative Analysis

Volumetric Analysis

(a) Determination of acetic acid in commercial vinegar using NaOH
(b) Determination of alkali content – antacid tablet using HCl.
(c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
(d) Estimation of hardness of water by EDTA.
(e) Estimation of ferrous and ferric by dichromate method.
(f) Estimation of copper using thiosulphate.

Gravimetric Analysis

Analysis of Cu as CuSCN and Ni as Ni (dimethylglyoxime).

Organic Chemistry

Laboratory Techniques

A. Thin Layer Chromatography

Determination of R_f values and identification of organic compounds.

(a) Separation of green leaf pigments (spinach leaves may be used).
(b) Preparation and separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2- and 3-one using toluene and light peucleum (40:60).
(c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).

B. Paper Chromatography: Ascending and Circular

Determination of R_f values and identification of organic compounds.

(a) Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid. Leucine and glutamic acid. Spray reagent – ninhydrin.
(b) Separation of a mixture of D, L – alanine, glycine, and L-Leucine using n-butanol:acetic acid:water (4:1:5). Spray reagent – ninhydrin.

(c) Separation of monosaccharides – a mixture of D-galactose and D – fructose using n-butanol:acetone:water (4:5:1). Spray reagent – aniline hydrogen phthalate.

Qualitative Analysis

Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.

Physical Chemistry

Transition Temperature

1. Determination of the transition temperature of the given substance by thermometric/dialometric method (e.g. $MnCl_2.4H_2O/SrBr_2.2H_2O$).

Phase Equilibrium

1. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the given phenol-water system.
2. To construct the phase diagram of two component (e.g. diphenylamine -benzophenone) system by cooling curve method.

Thermochemistry

1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH of the dissolution process.
2. To determine the enthalpy of neutralisation of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionisation of the weak acid/weak base.
3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born Haber cycle.

B.Sc. III Paper- I

Inorganic Chemistry

Maximum marks: 100(External 80+ Internal 20)

Learning Objectives: The course aim is to enhance the knowledge of transition metal complexes and acid base concepts

Unit - I

I. Metal-ligand bonding in Transition Metal Complexes

Limitation of valence bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal field parameters.

II. Thermodynamic and Kinetic Aspects of Metal Complexes

A brief outline of thermodynamic stability of metal complexes and factors affecting the stability. Substitution reaction of square planar complexes. Trans effect.

Unit - II

III. Magnetic Properties of Transition Metal Complexes

Types of magnetic behaviour, methods of determining magnetic susceptibility, spin only formula, L-S coupling, correlation of μ_S and μ_{eff} values. Orbital contribution to magnetic moments. Application of magnetic moment data for 3d metal complexes.

IV. Electronic spectra of Transition Metal Complexes

Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series. Orgel-energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

Unit - III

V. Organometallic Chemistry

Definition, nomenclature and classification of organometallic compounds.

Preparation, properties bonding and applications of alkyls and aryls of Li, Al, Hg and Sn.

Metal carbonyls: 18 electron rule, preparation, structure and nature of bonding in the metal carbonyls.

VI. Silicones and phosphazenes

Silicones and phosphazenes as examples of inorganic polymers. Nature of bonding in triphosphazenes.

Unit - IV

VII. Hard and Soft Acids and bases (HSAB)

Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness. Applications of HSAB principle, limitations of HSAB principle.

VIII. Bioinorganic Chemistry

Essential and trace elements in biological processes, metalloporphyrins with special reference to haemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+}.

Internal Assessment:

B.Sc. III Paper I

Inorganic Chemistry

Text Books (Theory Courses):

a. Concise Inorganic Chemistry, J.D. Lee, Blackwell Science Ltd.
b. Inorganic Chemistry, Puri, Sharma, Kalia and Kaushal.
c. Pradeep's Inorganic Chemistry, K.K. Bhasin, Pradeep Publication.
d. Chemistry for degree students, R. L. Madan

Reference Books:

a. Inorganic Chemistry, J.E.Huheey, Ellen A. Keiter, Richard L. Keiter, Addison Wesley Longman (Singapore) Pvt. Ltd.
b. Inorganic Chemistry, D.E.Shriver, P W. Atkins and C.H.L. Langford, Oxford.
c. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson and P.L. Gaus, Wiley.
d. Concepts of Models of Inorganic Chemistry, B.Douglas, D.McDaniel and J Alexander, John Wiley.
e. Inorganic Chemistry, WW. Porterfield, Addison - Wesley.
f. Inorganic Chemistry, A.G. Sharpe, ELBS
g. Inorganic Chemistry, G.L. Meissler and D.A. Tarr, Prentice-Hall.

B.Sc. III Paper – II

Organic Chemistry

Maximum marks: 100 (External 80 +Internal 20)

Learning Objectives: The purpose of study of organic chemistry is to know about the different organic compounds from which all living things are made up of. How they may be prepared and synthesized. By knowing about different organic compounds we can synthesize a wide variety of compounds which are not naturally found but they are very important for us

Unit - I

I **Spectroscopy**

Nuclear magnetic resonance (NMR) spectroscopy,

Proton magnetic resonance (^{1}H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of ^{1}H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone. Problems pertaining to the structures elucidation of simple organic compounds using UV, IR and ^{1}H NMR spectroscopic techniques.

Unit - II

II **Organometallic Compounds**

Organomagnesium compounds: the Grignard reagents, formation, structure and Chemical reactions.

Organozinc compounds: formation and chemical reactions.

Organolithium compounds: formation and chemical reactions.

III **Organosulphur Compounds**

Nomenclature, structural formation, Methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides & Sulphaguamidine.

IV **Heterocyclic Compounds**

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole.

Introduction to condensed five and six membered heterocycles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Nepieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Unit - III

V **Carbohydrates**

Classification and nomenclature, Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers, Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Determination of ring size of monosaccharides. Cyclic structure of D(+)-glucose. Mechanism of mutarotation.

Structures of ribose and deoxyribose.

An introduction to disaccarides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

VI **Amino Acids, Peptides, Proteins and Nucleic Acids**

Classification, structure and stereochemistry of amino acids. Acid-base behaviour, Isoelectric point and electrophoresis, Preparation and reactions of α–amino acids. Structure and nomenclature of peptides and proteins. Classification of proteins, Peptide structure determination, end group analysis, selective hydrolysis of peptides. Classical peptide synthesis, solid-phase peptide synthesis. Structures of peptides and proteins. Levels of protein structure, Protein denaturation/renaturation. Nucleic acids: Introduction. Constituents of ncleic acids. Ribonucleosides and ribonucleotides. The double helical structure of DNA.

Unit - IV

VII **Fats, Oils and Detergents**

Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils, Saponification value, iodine value, acid value, Soaps, synthetic detergents, alkyl and aryl sulphonates.

VIII **Synthetic Polymers**

Addition or chain-growth polymerization. Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers.

Condensation or step growth-polymerization. Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes.

Natural and synthetic rubborn.

IX **Synthetic Dyes**

Colour and constitution (electronic Concept), Classification of dyes. Chemistry and synthesis of Methyl orange, Conge red, Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo.

X **Organic Synthesis via Enolates**

Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis of ethyl acetoacetate: the Claisen condensation, Keto-enol tautomerism of ethyl acetoacetate.

Alkylation of 1,3-dithianes, Alkylation and acylation of enamines.

Text Books (Theory Courses):

a. Organic Chemistry, Vol. I, I.L. Finar, Pearson Education.
b. Organic Chemistry, M.K. Jain, Shoban Lal& Co.
c. Pradeep's Organic Chemistry, S.N. Dhawan, Pradeep Publication.

Reference Books:

a. Organic Chemistry, Morrison and Boyd, Prentice Hall.
b. Organic Chemistry, L.G. Wade Jr. Prentice Hall.
c. Fundamentals of Organic Chemistry Solomons, John Wiley.
d. Organic Chemistry, Vol. I, II, III S.M. Mukherji, S.P. Singh and R.P. Kapoor, Wiley Eastern Ltd. (New Age International)
e. Organic Chemistry, F.A. Carey, McGraw-Hill Inc.
f. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.

B.Sc. III Paper – III

Physical Chemistry

Maximum marks: 100 (External 80+ Internal 20)

Learning Objectives: Introductory Quantum mechanics, Spectroscopy, Physical Properties & Molecular Structure

U N I T - 1

I. Introductory Quantum Mechanics

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de Broglie's hypothesis, the Heisenberg's uncertainty principle, Hamiltonian operator.

II. Spectroscopy

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrophotometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

III. Physical Properties and Molecular Structure

Optical activity, polarization - (Clausius – Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties-paramagnetism, diamagnetism and ferromagnetics.

Unit II

IV. Elementary Quantum Mechanics

Schrodinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one-dimensional box.

Schrodinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions.

Molecular orbital theory, basic ideas – criteria for forming M.O from A.O., construction of M.O's by LCAO – H_2^+ ion, calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics. Hybrid orbitals – sp, sp^2, sp^3; calculation of coefficients of A.O's used in sp and sp^2 hybrid orbitals. Introduction to valence bond model of H_2, comparison of M.O. and V.B. models.

Unit III
(Spectroscopy)

V. Rotational Spectrum

Diatomic molecules: Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum

Infrared spectrum:Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman Spectrum: concept of polarizability, pure rotational and pure vibrational Raman spectra ofdiatomic molecules, selection rules.

Electronic Spectrum: Concept of potential energy curves for bonding and antibonding molecularorbitals, qualitative description of selection rules and Franck-Condon principle.

Qualitative description of σ, π^* and n M.O., their energy levels and the respectivetransitions.

Unit IV
(Photochemistry, Dilute Solutions, Colligative Properties and Solutions)

VI. Photochemistry

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, nonradiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples).

Dilute Solutions, Colligative Properties and Solutions

Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination, Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental me0thods for determining various colligative properties. Abnormal molar mass, degree of dissociation and association of solutes.

Solutions

Liquid – Liquid mixtures – Ideal liquid mixtures, Raoult's and Henry's law. Nonideal system-azeotropes –HCl-H_2O and ethanol – water systems.

Partially miscible liquids – Phenol-water, trimethylamine-water, nicotine-water systems. Immiscible liquids, steam distillation.

Internal Assessment

Books suggested (Theory Courses)

1. Physical Chemistry, G.M. Barrow, International Student Edition, McGraw Hill.
2. Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
3. The Elements of Physical Chemistry, P.W. Atkins, Oxford.
4. Physical Chemistry Through Problems, S.K. Dogra and S. Dogra Wiley Eastern Ltd.
5. Basic Inorganic Chemistry, F.A. Cotton 9 G. Willkinson and P.L. Gaus Wiley.
6. Concise Inorganic Chemistry, J.D. Lee, ELBS.
7. Organic chemistry, Morrison and Boyd, Prentice Hall.
8. Fundamentals of Organic Chemistry Solomons / John Wiley.

B.Sc. III Practicals

180 Hrs (6 Hrs/week)

INORGANIC CHEMISTRY

Synthesis and Analysis

(a) Preparation of sodium trioxalato ferrate (III), $Na_3[Fe(C_2O_4)_3]$ and determination of its composition by permaganometry.

(b) Preparation of Ni-DMG complex, $[Ni(DMG)_2]$.

(c) Preparation of copper tetraammine complex, $(Cu(NH_3)_4]SO_4$.

(d) Preparation of *cis*- and *trans*- bisoxalato diaqua chromate(III) ion.

Instrumentation

Colorimetry

(a) Job's method (b) Mole-ratio method

Adulteration – Food stuffs.

Effluent analysis, water analysis.

Solvent Extraction

Separation and estimation of Mg(II) and Fe(II))

Ion Exchange Method

Separation and estimation of Mg(II) and Zn(II).

ORGANIC CHEMISTRY

Laboratory Techniques

Steam Distillation

Naphthalene from its suspension in water

Clove oil from cloves

Separation of o-and p-nitrophenols

Column Chromatography

Separation of fluorescein and methylene blue

Separation of leaf pigments from spinach leaves

Resolution of racemic mixture of (±) mandelic acid

Qualitative Analysis

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

Synthesis of Organic Compounds

(a) Acetylation of salicylic acid, aniline, glucose and hydroquinone. Benzoylation of aniline and phenol

(b) Aliphatic electrophilic substitution

Preparation of iodoform from ethanol and acetone

(c) Aromatic electrophilic substitution

Nitration

Preparation of m-dinitrobenzene

Preparation of p-nitroacetanilide

Halogenation

Preparation of p-bromoacetanilide

Preparation of 2,4,6-tribromophenol

(d) Diazotizatoin/coupling

Preparation of methyl orange and methyl red

(e) Oxidation

Preparation of benzoic acid from toluene

(f) Reduction

Preparation of aniline from nitrobenzene

Preparation of m-nitroaniline from m-dinitrobenzene.

Stereochemical Study of Organic Compounds via Models

R and S configuration of optical isomers.

E, Z configuration of geometrical isomers.

Conformational analysis of cyclohexanes and substituted cyclohexanes.

PHYSICAL CHEMISTRY

Electrochemistry

(a) To determine the strength of the given acid conductometrically using standard alkali solution.

(b) To determine the solubility and solubility product of a sparingly soluble electrolyte conductometrically.

(c) To study the saponification of ethyl acetate conductometrically.

(d) To determine the ionisation constant of a weak acid conductometrically.

(e) To titrate potentiometrically the given ferrous ammonium sulphate solution using

$KMnO_4/K_2Cr_2O_7$ as titrant and calculate the redox potential of Fe++/Fe+++ system on the hydrogen scale.

Refractometry, Polarimetry

(a) To verify law of refraction of mixtures (e.g., of glycerol and water) using Abbe's refractometer.

(b) To determine the specific rotation of a given optically active compound.

Molecular Weight Determination

(a) Determination of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.

(b) Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy.

Colorimetry

To verify Beer – Lambert law for $KMnO_4/K_2Cr_2O_7$ and determine the concentration of the given solution of the substance.