

## B.Sc. III Paper I

### Inorganic Chemistry

#### Unit – I

##### I Metal-ligand Bonding in Transition Metal Complexes

Limitations 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 reactions of square planar complexes.

#### Unit – II

##### III Magnetic Properties of Transition Metal Complexes

Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula. L-S coupling, correlation of  $\mu_s$  and  $\mu_{\text{eff}}$  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  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  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, Sn.

Metal carbonyls: 18 electron rule, preparation, structure and nature of bonding in the mononuclear 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, electronegativity and hardness and softness.

##### VIII Bioinorganic Chemistry

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

## B.Sc. III Paper—II

### Organic Chemistry

#### Unit - I

##### I **Spectroscopy**

Nuclear magnetic resonance (NMR) spectroscopy, Proton magnetic resonance ( $^1\text{H}$  NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of  $^1\text{H}$  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  $^1\text{H}$  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 & Sulphaguamide.

##### 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 disaccharides (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  $\alpha$ -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 nucleic 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 rubber.

## IX **Synthetic Dyes**

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

## X **Organic Synthesis via Enolates**

Acidity of  $\alpha$ -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.

## B.Sc. III Paper III

### Physical Chemistry –

#### Unit I

#### (Introductory Quantum Mechanics, Spectroscopy, Physical Properties & Molecular Structure)

##### 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  $\sigma$ ,  $\sigma^*$ ,  $\pi$ ,  $\pi^*$  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 of diatomic molecules, selection rules.

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

**Qualitative description of  $\sigma$ ,  $\pi$  and n M.O.,** their energy levels and the respective transitions.

#### Unit IV

#### (Photochemistry, Solutions, Dilute Solutions and Colligative Properties)

##### 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, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples).

##### **Solutions, Dilute Solutions and Colligative Properties:**

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient.

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 methods for determining various colligative properties.

Abnormal molar mass, degree of dissociation and association of solutes.

## B.Sc. III Practicals

180 Hours (12 hours per week)

### INORGANIC CHEMISTRY

#### Synthesis and Analysis

- Preparation of sodium trioxalato ferrate (III),  $\text{Na}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$  and determination of its composition by permanganometry.
- Preparation of Ni-DMG complex,  $[\text{Ni}(\text{DMG})_2]$ .
- Preparation of copper tetraammine complex.  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$ .
- Preparation of *cis*- and *trans*- bisoxalato diaqua chromate(III) ion.

#### Instrumentation

##### Colorimetry

- Job's method
  - 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 ( $\pm$ ) mandelic acid

### **Qualitative Analysis**

Analysis of an organic mixture containing two solid components using water,  $\text{NaHCO}_3$ ,  $\text{NaOH}$  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) Diazotization/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

$\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  as titrant and calculate the redox potential of  $\text{Fe}^{++}/\text{Fe}^{+++}$  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  $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  and determine the concentration of the given solution of the substance.