

2. CHEMISTRY Scheme

Max Marks: 150

	Duration (hrs)	Max. Marks	Min. Pass Marks
Paper I	3	33	
Paper-II	3	33	36
Paper-III	3	34	
Practical	5	50	18

Note: Ten (10) questions are to be set taking two (02) questions from each unit. Candidates have to answer any 5 questions selecting at least one question from each unit.

CH-301 Paper-I : Inorganic Chemistry (2 hrs or 3 periods/ week)

Unit-I

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.

Unit-II

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.

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.

Unit-III

Electron 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 spectra of $[Ti(H_2O)_6]^{3+}$ complex ion.

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-IV

Organometallic Chemistry:

Definition, nomenclature and classification of organometallic compounds. Preparation,

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properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, a brief account of metallocenes and homogeneous hydrogenation, mononuclear carbonyls and the nature of bonding in metal carbonyls.

Unit-V

Bioinorganic Chemistry:

Essential and trace elements to 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+} . Nitrogen fixation.

Inorganic Polymers:

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

CH-302 Paper-II : Organic Chemistry (2 hrs or 3 periods/week)

Unit-I

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 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 structure elucidation of simple organic compounds using NMR data.

Organic Synthesis via Enolates: Acidity of α -hydrogens in reactive methylene compounds, alkylation of diethyl malonate and ethyl acetoacetate. Claisen condensation, Keto-enol tautomerism in ethyl acetoacetate. Synthetic applications of ethyl acetoacetate and malonic ester.

Unit-II

Heterocyclic Compounds

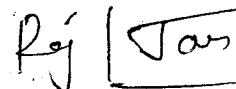
Introduction: Molecular orbital diagram and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. 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-Napieralski synthesis, Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Unit-III

Carbohydrates

Classification and nomenclature, Monosaccharides, mechanism of osazone formation. Epimers, anomers and mutarotation. Interconversion of glucose and fructose, chain lengthening and chain


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shortening of aldoses. Erythro and threodiastereomers. Conversion of glucose into mannose. Configuration of monosaccharides. Determination of ring size of monosaccharides. Formation of glycosides, ethers and esters. Cyclic structure of D(+)-glucose and fructose. Structures of ribose and deoxyribose. Nomenclature and structure of disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose); Glycosidic linkage.

Unit-IV

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.

Nucleic acids - Introduction, constituents of nucleic acids - nucleosides and nucleotides.

Unit-V

Organosulphur Compounds : Nomenclature, structural features, methods of formation and chemical reactions of thiols, sulphonic acids, sulphonamides and Sulpha drugs: sulphaguanidine, sulphadiazine (sulphapyrimidine), sulphamethoxazole, sulphacetamide.

Synthetic Polymers : Addition or chain-growth polymerization. Free radical and ionic polymerization. Ziegler-Natta Catalyst Condensation or step-growth polymerization. Polyesters, polyamides, phenol-formaldehyde resins, urea-formaldehyde resins, epoxy resins and polyurethanes. Natural and synthetic rubber.

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.

CH-303 Paper III: Physical Chemistry (2 Hrs. or 3 periods/week)

UNIT-I

Elementary quantum Mechanics:

Black-body, radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's mode of hydrogen atom (no derivation) and its defects. Compton effect.

De Broglie hypothesis, the Heisenberg's uncertainty principle, Sinusoidal wave equation, Hamiltonian operator, 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.

UNIT-II

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 level 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 these hybrid orbitals.

Introduction to valence bond model of H_2 , comparison of M.O. and V.B. models.

UNIT-III

Spectroscopy

Introduction: Electromagnetic radiation, spectrum, basic features of different spectrometers, statement of the Born-Openheimer approximation, degrees of freedom.

Rotational Spectrum: Diatomic molecules, Energy levels of a rigid rotator (semi-classical principles), selection rules, spectral intensity, using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotator, 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: Basic principles and applications, 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 Frank Condon principle. Qualitative description of σ , π and n M.O. their energy levels and the respective transitions.

UNIT-IV

Photochemistry

Interaction of radiation with matter, difference between thermal and photochemical processes.

Laws of photochemistry: Grothus-Draper 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).

Physical Properties and Molecular Structure

Optical activity, polymerization - (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 ferromagnetic.

UNIT-V

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 vapor 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 in freezing point. Thermodynamic derivation of relation between molecular weight and elevation of boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, degree of dissociation and association of solutes.

Practical: CH-304: Laboratory Course – III

(6 hrs/week)

INORGANIC CHEMISTRY

Synthesis and Analysis of:

- Potassium trioxalatoferrate (III), $K_3[Fe(C_2O_4)_3]$
- Bis(dimethylglyoximate) nickel (II) complex, $[Ni(DMG)_2]$
- Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4$
- Potassium *cis*-diaquabis(oxalato)chromate (III) dihydrate, $K[*cis*-Cr(H_2O)_2(C_2O_4)_2] \cdot 2H_2O$

Instrumentation:

Calorimetry

- Job's
 - 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 Fe (II)

ORGANIC CHEMISTRY

Laboratory Techniques

Steam Distillation

Naphthalene from its suspension in water
Clove oil from Clove
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, $NaHCO_3$, for separation and preparation of suitable derivatives.

Synthesis of Organic Compounds

- Acetylation of salicylic acid, aniline, glucose and hydroquinone.


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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.

Stereochemistry: 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 ionization 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 $\text{Fe}^{2+}/\text{Fe}^{3+}$ system on the hydrogen scale.

Refractometry, Polarimetry

(a) To verify the law of refraction of mixture (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

(a) To verify Beer-Lambert law $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ and determined the concentration of the given solution of the substance.