

Syllabus for B.Sc. I
FIRST PAPER
INORGANIC CHEMISTRY

1. ATOMIC AND NUCLEAR STRUCTURE (12)

- (a) Bohr's and Sommerfelds' Atomic Models, de Broglie equation, Heisenberg uncertainty principle. Schrodinger wave equation, Radial and angular wave function, Physical significance and characteristics of a wave function, shapes of s, p, d and f-orbitals. Aufbau principle and electronic configuration of atoms. Periodic classification of elements (IUPAC recommendation), Long form of the periodic table including transactinoid elements.
- (b) nuclear stability-N/Z ratio and binding energy.

2. PROPERTIES OF THE ELEMENTS (12)

Atomic, Covalent and Ionic radii, Ionization potential, Electron affinity, Electronegativity including idea about group electronegativity and their variation in the Periodic table. Ionisation Potential, Lattice energy and hydration energy and their relation to solubility of ionic compounds.

3. CHEMICAL BONDING (12)

Ionic, covalent (polar and non-polar), coordinate bonds, sigma and pi-bonds, odd electron bonds, hydrogen bond, van der Waals forces and metallic bond. Covalent character in ionic bonds (Fajans' rules), partial ionic character of a covalent bond.

4. CO-ORDINATION CHEMISTRY (10)

co-ordination compounds, Werner's theory, Sidgwick's concept of effective atomic number (EAN), IUPAC system of nomenclature of co-ordination compounds. Types and classification of ligands.

5. ELECTRODE POTENTIAL (10)

Electrode potential and importance of electrochemical series. Electrode potential diagramme and its applications.

6. PREPARATIONS, PROPERTIES AND USES OF : (8)

- (a) Heavy water, lithium tetrahydroaluminate, lithium stearate, basic beryllium acetate.
(b) Structure and Bonding of :

H_2O_2 , $Be(BH_4)_2$, $BeMe_2$, Anhydrous beryllium chloride, basic beryllium acetate, polymeric $Ca(C_5H_5)_2$.

Reference Books:

1. Inorganic Chemistry by Puri Sharma and Kalia.
2. Concise Inorganic Chemistry by J.D. Lee.
3. Inorganic Chemistry by Gurdeep Raj.

B. Sc. I

ORGANIC CHEMISTRY

1. STRUCTURE AND BONDING:

Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, resonance, hyper conjugation, aromaticity, inductive and hydrogen bonding.

2. MECHANISM OF ORGANIC REACTIONS:

Homolytic and heterolytic bond breaking, Types of reagents electrophiles and nucleophiles, Types of organic reactions, Energy consideration, Reactive intermediates: carbocations, carboanions, free radicals, carbenes, and arynes.

3. STEREOCHEMISTRY OF ORGANIC COMPOUNDS:

Concept of isomerism, types of isomerism.

Optical isomerism :elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, diastereomers, threo and erythro, diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization.

Relative and absolute configuration, sequence rules, **D & L** and **R & S** system of nomenclature. Geometrical Isomerism. E&Z system of nomenclature of geometrical isomers.

Conformational isomerism: Conformational analysis of n-butane, conformations of cyclohexane, axial and equatorial bonds, Newman projection and Fischer formulae.

4. ALKANES AND CYCLOALKANES:

Methods of formation: (with special references to Wurtz reaction, Kolbe reaction, Corey House reaction and decarboxylation of carboxylic acids) and chemical reactions of alkanes. Mechanism of free radical halogenations of alkanes: orientation, reactivity and selectivity. Baeyer strain theory and its limitations.

5. ALKENES, DIENES AND ALKYNES:

Alkenes: Methods of formation, mechanisms and dehydration of alcohols and dehydrohalogenation of alkyl halides. The Saytzeff Rule, Hofmann elimination and relative stabilities of alkenes.

Chemical reactions of alkenes-mechanisms involved in hydrogenation, electrophilic and free radical additions. Markownikoff's addition, hydroboration oxidation, oxymercuration reduction, Epoxidation, Ozonolysis, Hydration and hydroxylation, Substitution at the allylic position of alkenes. Structure of butadiene, methods of formation. Chemical reaction-1, 2 and 1, 4-addition. Diels Alder reaction.

Alkynes: methods of formation. Chemical reactions of alkynes, acidity of alkynes, mechanism of

electrophilic and nucleophilic addition reaction, hydroboration oxidation and metalammonia reductions.

6. ARENES AND AROMATICITY:

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 (Mechanism). Role of sigma and pi complexes. Mechanism of Friedel-Crafts reaction and deactivating substituents, orientation.

7. ALKYL HALIDE AND ARYL HALIDES: Mechanism of SN^1 and SN^2 reactions of Alkyl halides, Mechanism of addition-elimination and elimination-addition mechanisms of nucleophilic substitution reactions of aryl halides.

Reference Books:

1. Organic Chemistry by Jagdamba Singh (Vol-1)
2. Organic Chemistry by M.K. Jain
3. Organic Chemistry by Morrison & Boyd

B. Sc. (Physical Chemistry) For Session 2020-2021 Only

B.Sc. Part-I

1. GASES

Kinetic theory of gases and gas laws, specific heat ratio C_p/C_v . Non-ideality of gas behavior, Van der Waals equation of state, critical constants and their determination. Law of corresponding states, Maxwell Law of distribution (Quantitative treatment).

2. THE FIRST LAW OF THERMODYNAMICS

Thermodynamic terms and statement of the first law, thermodynamic reversibility and maximum work, enthalpy of a system, heat capacity at constant volume and constant pressure. Extensive and intensive properties, state functions and exact differentials, cyclic rule. Variation of internal energy with temperature and volume, enthalpy as a function of temperature and pressure, relation between C_p and C_v . Joule-Thomson effect, Van der Waals equation and J-T effect. Important thermodynamic properties (W , Q , E and H) in an isothermal expansion of an ideal gas and adiabatic expansion of an ideal gas.

3. CHEMICAL KINETICS:

Reaction rate, order and molecularity of reaction, zero, first, second and third order reactions. Methods of determining the order of a reaction, Complex reactions-opposing reactions, consecutive reactions and side reactions with reference to first order reactions. Energy of activation and collision theory of bi-molecular reactions.

4. ELECTROCHEMISTRY:

Electrolytic conductance, equivalent conductance, molecular conductance, variation of conductance with concentration, Qualitative treatment of interionic attraction theory. Ionic mobilities and transport number, determination of transport number (Hittorf and moving boundary method), Some applications of conductance measurements, hydrolysis of salts, pH and pK_a , acid-base concept in non-aqueous media, Buffer solutions.

5. THERMOCHEMISTRY AND CHEMICAL EQUILIBRIUM

Hess's law and its applications, Bond energy and resonance energy, Law of mass action and its applications to homogeneous and heterogeneous equilibria.

Recommended Books:

1. Physical Chemistry by R L Madan
2. A Textbook of Physical Chemistry by A. S. Negi and S. C. Anand.
3. Advanced Physical Chemistry by Gurdeep Raj.
4. Advanced Physical Chemistry Book by D. N. Bajpai.
5. Principles of Physical Chemistry by B. R. Puri, Madan S. Pathania and L. R. Sharma

SYLLABUS FOR B. Sc.-I

CHEMISTRY PRACTICAL

1. Analysis of inorganic mixture including insoluble and interfering radicals (Three radicals only). 12 Marks
2. Use of $K_2Cr_2O_7$ (Determination of iron) and Iodometry and Iodimetry (Determination of Copper, dichromate, permanganate) 12 Marks
3. Detection of functional group or element in the given compound. 16 Marks

Record and viva-voce (5+5) = 10 Marks

Syllabus for B.Sc. II for 2020-2021

FIRST PAPER INORGANIC CHEMISTRY

1. SHAPES OF MOLECULES (12)

Hybridization of orbitals and directional nature of covalent bond. Sidwick – Powell theory. Valence Shell Electron Pair Repulsion (VSEPR) theory, shapes of inorganic molecules and anions such as BeCl_2 , BF_3 , InCl^{2-}_5 , SiF_4 , NH_3 , H_2O , OF_2 , Cl_2O , ClO_2 , PCl_3 , PCl_5 , SF_4 , ClF_3 , ICl_3 , PPh_3 , IF_7 , XeF_4 , XeF_6 , CO_3^{2-} , NO_3^- , PO_4^{3-} , ClO_4^- , SbF_4^- , SbF_5^{2-} , XeF_5^+ , I_3^- and I_3^+ related species.

2. p-BLOCK ELEMENTS (10)

Characteristic : Chemical reactivity of elements and group trends. Synthesis, properties and structure of their hydrides and halides. Application of redox potential diagrams with reference to N, P, S, Cl, Br and I.

3. p-BLOCK ELEMENTS (10)

Compounds : Allotropy of boron, carbon, phosphorus and sulphur. Peroxocompounds of B, C and S oxyacids of N, P, S and halogens interhalogens, pseudohalogens and polyhalides.

4. d-BLOCK ELEMENTS (10)

Transition elements: General characteristics, variable oxidation states, complex formation, colour, magnetic properties and catalytic properties. Comparative account of 3d, 4d and 5d, transition metals with respect to their atomic and ionic sizes, stability of oxidation states and magnetic properties.

5. COORDINATION CHEMISTRY (8)

Isomerism in coordination compounds (definitions and some typical examples). Stereochemistry of metal complexes involving coordination number 3 to 7.

6. INORGANIC COMPOUNDS – PREPARATION, PROPERTIES AND USES OF (12)

Borides, Diborane, Fibrous Alumina and Zirconia, Silanes, Ultrapure Si and Ge. Hydrazine, Hydroxylamine. Hydrazoic acid. Trialkyl and Triarylphosphates. Potassium hexacyanoferrate (II) and (III). Sodium hexanitrocobaltate (III).

Reference Books:

1. Inorganic Chemistry by Puri Sharma and Kalia.
2. Concise Inorganic Chemistry by J.D. Lee.
3. Inorganic Chemistry by Gurdeep Raj.

B. Sc. II

ORGANIC CHEMISTRY

1. ELECTROMAGNETIC SPECTRUM: ABSORPTION SPECTRA

Ultraviolet (UV) Absorption Spectroscopy- Absorption laws, molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation, concept of auxochromes and chromophore, Bathochromic, hypsochromic, hyperchromic, and hypochromic shifts. UV spectra of conjugated enes and enones.

Infrared (IR) absorption spectroscopy-Molecular vibrations, Hook's law, selection rules, intensity and position of IR bands, measurement of IR spectrum fingerprint region, characteristic absorption of various functional groups and interpretation of IR spectra of simple organic compounds.

2. ALCOHOLS:

Monohydric alcohols- Methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters, Reactions of alcohols. Dihydric alcohols-Methods of formation, and chemical reactions of vicinal glycols, oxidative cleavage [$\text{Pb}(\text{OAc})_4$ and HIO_4] and Pinacol-Pinacolone rearrangement.

3. PHENOLS:

Preparation of phenol, acidic character, Comparative acidic strengths of alcohol and phenol, resonance stabilization of phenoxide ion. Reactions of phenols- electrophilic aromatic substitution, acylation and carboxylation, mechanism of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben- hoesch reaction and Raimier - Tiemann reaction.

(b) ETHERS AND EPOXIDES :

Ether- Williamson's synthesis, Reaction with HX.

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

(c) ALDEHYDES AND KETONES:

Synthesis of aldehydes and ketones with particular reference to the Synthesis of aldehydes from acid chlorides, Synthesis of aldehydes and ketones using 1, 3 dithianes, Synthesis of ketones from nitriles and from carboxylic acids.

Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensation. Condensation with ammonia and its derivatives.

Wittig reaction, Mannich reaction.

Use of acetal as protecting group. Oxidation of aldehydes, Bayer-Villiger oxidation of ketones, Cannizzaro reaction, Clemmensen, Wolff- Kishner, LiAlH_4 and NaBH_4 reductions, Halogenation of enolizable ketones.

6. CARBOXYLIC ACIDS:

Acidity of carboxylic acid. Effects of substituents on acidic strength. Preparation of carboxylic acid. Reaction of carboxylic acid. Hell- Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides. Reduction of carboxylic acid. Mechanism of decarboxylation.

7. CARBOXYLIC ACID DERIVATIVES:

Nucleophilic acyl substitution and relative reactivities of acyl derivatives.

8. ORGANIC COMPOUNDS OF NITROGEN: Structural features affecting basicity of amines. Hofmann bromamide reaction. Synthetic transformations of aryl diazonium salts, azo coupling.

Reference Books:

1. Organic Chemistry by Jagdamba Singh (Vol-2)
2. Organic Chemistry by M.K. Jain
3. Organic Chemistry by Morrison & Boyd

1.THERMODYNAMICS

Spontaneous processes, Carnot cycle, statement of second law, concept of entropy, combined form of the first and second law of thermodynamics, enthalpy and entropy. Entropy change in isolated system. Variation of entropy with temperature and volume, Variation of entropy with temperature and pressure. Helmholtz and Gibbs free energies, properties of Gibbs function, Gibbs-Helmholtz equation. Thermodynamic criteria of equilibrium, Clapeyron- Clausius equation and its application.

2.PHASE EQUILIBRIA

Explanation of phase, component and degree of freedom. Phase rule and its application to one component system (water and Sulphur) and two component (single eutectics) systems. Nernst distribution law, Limitations and applications of the distribution law.

3.ELECTROCHEMICAL CELLS:

Reversible and irreversible cells, EMF of a cell and free energy change, Nernst equation. EMF and equilibrium constant. Concept of concentration cell without transference. Applications of EMF measurements (determination of solubility product, pH, dissociation constant of acids, hydrolysis constant, solubility of sparingly soluble salts).

4.SURFACE PHENOMENON:

Physical and chemical adsorption, Freundlich adsorption isotherm, Gibbs adsorption equation, Langmuir monomolecular theory.

5.COLLOIDAL STATE:

Stability of colloids, determination of size of colloidal particles, Electrokinetic potential (Zeta potential). Donnan membrane theory and its applications.

Recommended Books:

- 1.** Physical Chemistry by R L Madan
- 2.** A Textbook of Physical Chemistry by A. S. Negi and S. C. Anand.
- 3.** Advanced Physical Chemistry by Gurdeep Raj.
- 4.** Advanced Physical Chemistry Book by D. N. Bajpai.
- 5.** Principles of Physical Chemistry by B. R. Puri, Madan S. Pathania and L. R. Sharma

1. Gravimetric Analysis: 10 Marks
- (i) Ba as BaSO₄
 - (ii) Zinc as ZnO
 - (iii) Cu as CuO
2. Organic Preparation (one step and crystallization) 15 Marks
- (i) Osazone formation
 - (ii) Azo-dye formation
 - (iii) Picrate formation
3. Physical Chemistry Experiments 15 Marks
- (i) Experiments of surface tension (using stalagmometer)
 - (ii) Experiments on viscosity (using viscometer) (iii) Partition coefficient determination
- Record and viva-voce (5+5) = 10 Marks**

FIRST PAPER

INORGANIC CHEMISTRY

1. THEORIES OF COVALENT BOND (12)

Valence bond theory-Heitler-London and Pauling-Slater theories and resonance, Molecular orbital theory-LCAO method, bonding, non-bonding and antibonding molecular orbitals. Molecular orbital energy level diagrams for homonuclear and heteronuclear diatomic molecules-electronic structure, bond order, bond length and bond energy.

2. THEORIES OF COORDINATE BOND (12)

Valence bond theory and its limitations. Crystal field theory-d-orbital splitting in octahedral and tetrahedral crystal fields. Ligand field splitting ($10Dq$) and factors affecting its magnitude, spectrochemical series. Crystal field stabilization energies (CFSE) for d^1 to d^{10} systems in octahedral and tetrahedral fields.

3. 4 f-BLOCK ELEMENTS (10)

Characteristics: Electronic structure, lanthanide contraction and its consequences, oxidation states, complex formation, magnetic and spectral properties and their differences from transition metals, ion exchange and solvent extraction methods of separation of lanthanides.

4. INORGANIC CHAINS, RINGS AND CAGES (8)

Silicates, Silicones, Borazines, Phosphazenes, S-N compounds and Boranes.

5. STRUCTURES AND CHARACTERISTICS OF SOLIDS (10)

Metallic, Ionic, Covalent and molecular crystals, Structures of ionic solids, radius ratio rules, Structures of metals, close packed structures, Characteristics of Unit Cells.

6. ENVIRONMENTAL POLLUTION (8)

Air pollutants, their sources and toxic effects. Particulates, their sources and toxic effects. Acid rain and green house effects. Water pollutants.

7. METAL IONS IN BIOLOGICAL SYSTEMS (8)

Essential and trace elements. Chemistry of chlorophyll, haemoglobin, myoglobin, and cyanocobalamin.

Reference Books:

1. Inorganic Chemistry by Puri Sharma and Kalia.
2. Concise Inorganic Chemistry by J.D. Lee.
3. Inorganic Chemistry by Gurdeep Raj.

ORGANIC CHEMISTRY

1. SPECTROSCOPY

Nuclear magnetic resonance {NMR} spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constant, area of signals, interpretation of PMR spectra of simple organic molecule such as ethyl bromide, ethanol, acetaldehyde, ethyl acetate, toluene and acetophenone.

Problems pertaining to the structure elucidation of organic compounds using UV, IR and PMR spectroscopic techniques.

2. ORGANOMETALLIC COMPOUNDS:

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

Organolithium Compounds: formation and chemical reactions

3. ORGANOSULPHUR COMPOUNDS:

Methods of formation and chemical reactions of sulphonic acids, sulphonamides and sulphaguani-dine.

4. 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 reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole.

5. ORGANIC SYNTHESIS VIA ENOLATE:

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.

6. CARBOHYDRATES:

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

7. AMINO ACIDS, PEPTIDES AND PROTEINS:

Amino acids: acids – base behavior, isoelectric point and electrophoresis, Preparation and reactions of – amino acids. End group analysis. Solid –phase peptide synthesis.

8. 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, **Natural and Synthetic rubbers.**

Reference Books:

1. Organic Chemistry by Jagdamba Singh (Vol-3)
2. Organic Chemistry by M.K. Jain
3. Organic Chemistry by Morrison &

B.Sc. Part-III: PHYSICAL CHEMISTRY PAPER-THIRD

1. THERMODYNAMICS:

Thermodynamic derivation of the law of mass action. Reaction isotherm and Van't Hoff equation (influence of temperature on equilibrium constant K), Thermodynamic derivation of phase rule. Chemical potential, Gibbs-Duhem equation, Effect of temperature on chemical potential. Effect of pressure on chemical potential, Chemical potential of real gases and fugacity of real gases. Colligative properties (thermodynamic treatment).

2. CHEMICAL KINETICS AND CATALYSIS:

Steady state approximation, Lindemann's theory of unimolecular reactions, Quantitative treatment of transition state theory of reaction rates, Primary salt effect in ionic reactions. Kinetics of homogeneous, acid-base and enzyme catalysis, heterogeneous catalysis, negative catalysis and inhibition. Effect of pH and temperature on enzyme catalyzed reactions, Effect of temperature on surface reactions, promoters and poisons.

3. PHOTOCHEMISTRY:

Absorption of light, chain reactions, free radical chains (Rice-Herzfeld mechanism for the decomposition of ethane), Lambert's and Beer's law, Einstein's law of photochemical equivalence and quantum efficiency. Kinetics of decomposition of acetaldehyde and dimerization of anthracene. Photosensitization.

4. E.M.F.:

Concentration cells with and without transference, Liquid junction potential, Fuel cells.

5. ATOMIC STRUCTURE AND NUCLEAR CHEMISTRY:

Bohr's theory, Dual nature of electron and de Broglie equation, Heisenberg's uncertainty principle. One dimensional Schrodinger's wave equation and physical significance of wave function. Radioactive decay and equilibrium, Natural and artificial radioactivity, Radioactive series, Nuclear binding energy, radioactive isotopes, fission and fusion products.

Recommended Books:

1. Physical Chemistry by R L Madan
2. A Textbook of Physical Chemistry by A. S. Negi and S. C. Anand.
3. Advanced Physical Chemistry by Gurdeep Raj.
4. Advanced Physical Chemistry Book by D. N. Bajpai.
5. Principles of Physical Chemistry by B. R. Puri, Madan S. Pathania and L. R. Sharma

SYLLABUS FOR B. Sc.-III

CHEMISTRY PRACTICAL

1. Organic analysis of industrial importance 20 Marks
 - (i) Identification of simple organic compound
 - (ii) Paper chromatographic separation of amino acids and sugars (only binary mixtures)

2. Physical Chemistry Experiments 25 Marks
 - (i) Acid or alkaline hydrolysis of esters.
 - (ii) Acetone-iodine reaction catalyzed by H^+ ions
 - (iii) Adsorption of acetic acid on charcoal
 - (iv) Heat of solution of a substance (oxalic acid) by solubility method
 - (v) Molecular weight determination of a volatile substance by Duma's method

3. Inorganic analysis and preparation
 - (i) Determination of hardness of water
 - (ii) Preparation of simple inorganic complexes
 - (iii) EDTA titrations of Ca^{2+} , Mg^{2+} , Zn^{2+} and Cu^{2+} .
Paper-chromatographic separation of metal ions – Pb^{2+} , Zn^{2+} , Cu^{2+} , Ni^{2+} , Cd^{2+} ions (binary mixtures only)