

# B.Sc. 2<sup>nd</sup> Year Chemistry

*Max. Marks: 75*

*Internal Max: 25*

*Total Duration: (150 hours)*

*Min. Marks: 27*

*Internal Min: 09*

## Section-A

### **Unit-I: Inorganic Chemistry-I (25 hours)**

**s-Block Elements:-** Chemical Reactivity: towards water, oxygen, hydrogen, nitrogen and halogens. Anomalous behaviour and diagonal relationships (Lithium, Beryllium, Magnesium and Aluminum). Chemical characteristics of the compounds of alkali and alkaline earth metals (oxides, hydroxides and oxoacids).

Hydrides: Classification and general properties.

Some commercially important compounds:- Sodium carbonate, Calcium carbonate and Calcium sulphate (Preparation, properties and Uses)

**Nuclear Chemistry:-** Nuclear Reactions: Types, Compound nucleus, Threshold energy and Nuclear cross section.

**Isotope Separation Methods:-** Gaseous and thermal diffusion; electromagnetic and chemical exchange methods.

**Applications of Radioisotopes:-** Chemistry, Industry, Agriculture and Medicine. Neutron activation and Isotope dilution analyses.

**Detection and measurement of radiation:-** Gas ionization detectors and Scintillation counters.

**Radiation Chemistry:** Units of radiation; LET and G-Value. Radiation Chemistry of oxygen and water.

### **Unit-II: Inorganic Chemistry-II (25 hours)**

#### **p-Block Elements - Groups (13-15).**

**Boranes:-** Nomenclature, Classification, Preparation, Properties, Structure and Bonding with special reference to diborane.

**Bonding in higher boranes:-** Types of bonds, Empirical rules for bonding in boron clusters.

Introductory concept about carboranes and metallocarboranes.

**Carbides:-** Classification, Preparation, Properties and Uses. Intercalation compounds of graphite

**Clathrates:-** Types, Preparation and Stability.

**Nitrogen Compounds:-** Preparation, properties and uses of hydrazine, hydroxylamine and oxides of nitrogen.

**Ammonia:-** As a non-aqueous solvent.

### **p-Block Elements - Groups (16-18).**

**Oxygen:-** Chemistry of different forms (atomic , molecular and ozone).

Oxides, oxygen fluorides and oxyacids of sulphur: Properties, Structure & Bonding.

**Hydrogen Peroxide:-** Preparation , Properties and Uses.

**Halogens:-** Comparative chemical reactivity, Types, Properties, Structure & Bonding of hydrogen halides, Interhalogens and Polyhalides.

Oxyacids of Chlorine: Structure and Bonding.

**Noble gases:-** Isolation and importance of noble gases in theoretical chemistry.

Fluoride, oxides and oxyfluorides of Xenon: Structure and bonding (VB and MO treatment)

## **Section-B**

### **Unit-III: Organic Chemistry-I**

**(25 hours)**

**Alcohols:-** Classification. Methods of formation of monohydric alcohols through reduction of aldehydes, ketones, carboxylic acids and esters using different reducing agents including mechanistic details of the reactions involved. Reactions of alcohols including Pinacole-Pinacolone rearrangement with mechanism. Methods of formation and the oxidative cleavage reactions of diols.

**Phenols:-** Characteristic features of Phenols. Mechanisms of Fries and Claisen rearrangements and Gatterman, Huben-Hoesch, Veils-Meir-Haack and Riemer-Tieman reactions.

**Epoxides:-** Methods of formation and mechanism of acid/base catalysed ring openings of epoxides. Reactions of Grignard and organolithium reagents with epoxides.

**Ethers:** Mechanisms involved in the synthetic procedures of ethers, their cleavage and auto-oxidation.

**Aldehydes and Ketones:** Structure and reactivity of carbonyl groups. Synthesis of aldehydes starting from acid chlorides and those of ketones from nitriles, carboxylic acids and 1,3-dithianes. Stereochemistry and mechanism of nucleophilic additions to carbonyl groups. Cram's rule.

Mechanisms involved in Benzoin, Aldol/Cross Aldol, Perkin, Knoevenegal, Cannizzaro and Mannich condensations/reactions. Meerwein-Ponndorf-Verly, Clemmenson and Wolf-Kishner **reductions** and Baeyer-Villegar & Oppenaur **oxidations**. Mechanisms of acid and base catalysed halogenation in aldehydes and ketones.

### **Unit-IV: Organic Chemistry-II**

**(25 hours)**

**Carboxylic acids and their derivatives:** Structure of carboxylic group. Factors affecting strength of carboxylic acids. Mechanistic details of preparation of carboxylic acids using Grignard

reagent and from hydrolysis of nitriles. Mechanisms involved in the HVZ reaction, conversion of acids to corresponding chlorides, esters, anhydrides and amides. Relative stabilities and interconversion of acid derivatives into one another. Reduction of carboxylic acids and their derivatives. Transesterification and hydrolysis of esters.

Applications of Ethylacetoacetate and Malonic ester in organic synthesis.

Methods of formation, important properties and uses of Malic, Tartaric, citric, Oxalic and Maleic acids.

### **Nitrogen bearing compounds:**

**Amines:** Classification and factors affecting basicity of amines. Mechanistic details (wherever applicable) of methods of formation of alkyl and arylamines through reduction of nitro compounds and nitriles, Gabriel-Phthalamide reaction and Hofmann rearrangement. Mechanisms involved in the formation and reactions of arenediazonium salts including Azo coupling.

**Nitroarenes:** Methods of formation and mechanism of nucleophilic aromatic substitution reaction in nitroarenes.

**Heterocyclic compounds bearing one nitrogen atom:** Structural features of pyrrole, pyrrolidine, pyridine and piperidine and comparative account of their basic strength. Aromaticity and electrophilic substitution reactions of pyrrole and their comparison with those of furan and thiophene. Mechanisms involved in the preparations of Indole and quinoline using Fischer-Indole and Bishler-Napierlaski syntheses.

## **Section-C**

### **Unit-V: Physical Chemistry-I**

**(25 hours)**

**Thermodynamics:** Thermodynamic functions: State and path functions and their differentials. Thermodynamic processes. Concept of heat and work. Heat capacity, heat capacities at constant volume and constant pressure and their relationship. Joule's law, Joule-Thomson coefficient and inversion temperature. Calculation of  $\Delta U$  &  $\Delta H$  for the expansion of ideal and non-ideal (van der Waals) gases under isothermal and adiabatic conditions.

Bond dissociation energy and its calculation from thermo-chemical data with applications. Temperature dependence of enthalpy, Kirchhoff's equation.

**Second law of thermodynamics:** Need for the law, different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature.

Concept of entropy, entropy as a function of V&T, and as a function of P&T. Clausius inequality; entropy as criteria for spontaneity and equilibrium. Entropy change in physical processes, ideal gas expansion and entropy of mixing of ideal gases.

**Third law of thermodynamics:** Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, Nernst heat theorem, third law of thermodynamics, concept of residual entropy, evaluation of absolute entropy from heat capacity data.  $\Delta G$  &  $\Delta A$  as criteria for thermodynamic equilibrium and spontaneity. their advantage over entropy change. Variation of G and A with P, V and T, Gibbs-Helmholtz equation.

**Equilibrium:** Equilibrium constant and free energy change. Thermodynamic derivation of law of mass action.

Reaction isotherm and reaction isochore, Clapeyron equation and Clausius-Clapeyron equation, applications.

**Phase rule:** Meaning of the terms: phase, component and degree of freedom, statement and derivation of Gibbs phase rule, phase diagrams of one component system – water and sulphur systems.

Phase equilibria of two component system: solid-liquid equilibria, simple eutectic system (Pb-Ag), desilverisation of lead.

Solid solutions - compound formation with congruent melting point (Mg-Zn) and incongruent melting point (FeCl<sub>3</sub>-H<sub>2</sub>O systems). Freezing mixtures, acetone- dry ice.

Liquid-liquid mixtures: Ideal liquid mixtures, Raoult's and Henry's law. Non-ideal systems, azeotropes (HCl-H<sub>2</sub>O and C<sub>2</sub>H<sub>5</sub>OH-H<sub>2</sub>O systems.)

Partially miscible liquids: Lower and upper consolute temperatures, (examples of Phenol-water, trimethylamine-water, nicotine-water systems).

**Nernst distribution law:** statement and thermodynamic derivation, applications.

## **Unit-VI: Physical Chemistry-II**

**(25 hours)**

**Electrochemistry:** Migration of ions and Kohlrausch's law, Arrhenius theory of electrolyte dissociation and its limitations. Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment without derivation). Transport number, definition and determination by Hittorf's and moving boundary methods. Application of conductivity measurements: determination of degree of dissociation and dissociation constants of acids, solubility product of a sparingly soluble salt, conductometric titrations.

Types of reversible electrodes (half-cells): metal-metal ion, gas-metal-ion, metal-insoluble salt-anion and redox electrodes. Standard hydrogen electrode, glass electrode, reference electrodes (calomel, Ag/AgCl) . Electrode reactions, Nernst equation and cell E.M.F. Electrochemical series and its significance.

Electrolytic and Galvanic cells. Measurement of EMF of a cell.

Concentration cells, electrolyte concentration cell (with and without transport), electrode concentration cell.

Application of standard potentials: determination of thermodynamic functions of cell reactions ( $\Delta G$ ,  $\Delta H$  and  $K$ ), pH and pK<sub>a</sub>, solubility product and activity coefficient; potentiometric titrations.

### **Books Recommended:**

1. Basic Inorganic Chemistry ; F.A . Cotton ; G. Wilkinson & P.L. Gauss ; Wiley, 3<sup>rd</sup> edn., 2002.
2. Inorganic Chemistry ; A.G. Sharpe; ELBS, 3<sup>rd</sup> edn., 1992.
3. Concise Inorganic Chemistry ; J.D. Lee; ELBS, 5<sup>th</sup> edn., 2003
4. Advanced Inorganic Chemistry ; Volume 1; S. Prakash; G.D. Tuli ; S.K. Basu & R.D . Madan; S.Chand & Company Ltd.
5. Essentials of Nuclear Chemistry ; 2nd edn. ; Arniker ; 1967.
6. Principles of Radiation chemistry ; O. Donnell & Sangster; Edward Arnold ; 1970.
7. Introduction to Nuclear Chemistry., D.J.Carswell; Elsevier; 1967.
8. Organic chemistry; Vol I & II ; 31st edn; I.L. Finar ; LPE; Pearson Education.
9. Organic chemistry; Morrison and Boyd ; Prentice Hall, 6<sup>th</sup> edn., 2003.
10. Organic chemistry; I.G. Wade ; Prentice Hall, 5<sup>th</sup> edn., 2004.
11. Fundamentals of Organic chemistry; 5th edn; Solomans ; John-wiley.
12. Organic chemistry; Vols I, II & III; Singh; Mukherji & R.P. Kapoor ;Wiley-Eastern.
13. Text book of Organic Chemistry; R.K. Bansal ;Wiley-Eastern;1997, 4<sup>th</sup> edn., 2003.
14. Advanced Organic Chemistry; B.S. Bahl and Arun Bahl; S. Chand;1996.
15. The Elements of Physical Chemistry; P. W. Atkins; Oxford, 2<sup>nd</sup> edn., 1992.
16. Physical Chemistry; G. M. Barrow; McGraw-Hill; International Student edition, 5<sup>th</sup> edn., 1992
17. Physical Chemistry; R. A. Alberty,;Wiley, Eastern Ltd.
18. Essentials of Physical Chemistry Vols III & IV; K. L. Kapoor ;Macmillan India Ltd, 2<sup>nd</sup> edn., 2005.
19. Principals of Physical Chemistry; Puri, Sharma and Pathania ; S. Nagin Chand &Co, 44<sup>th</sup> edn., 2011.
20. Physical Chemistry through Problems; S. K. Dogra ; Wiley Eastern Ltd, 1991.
21. University general Chemistry; C. N. R. Rao; MacMillan.

## Laboratory Course

*Max. Marks: 25*  
*Internal Max: 25*

*Min. Marks: 09*  
*Internal Min: 09*

### A. Inorganic Chemistry

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

#### *Volumetric Analysis:*

- a) Determination of acetic acid concentrations in commercial vinegar using NaOH.
- b) Determination of alkali content in antacid tablets using HCl.
- c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
- d) Estimation of hardness of water by EDTA.

#### *Gravimetric Analysis:*

Estimation of Cu as CUSCN and Ni as Ni-Dimethylglyoxime

### B. Organic Chemistry :

#### *Paper Chromatography:*

- a) Separation of a mixture of phenylalanine – glycine and Alanine – aspartic acid .  
Spray reagent – Ninhydrin ; Solvent Butanol / Acetone / H<sub>2</sub>O.
- b) Separation of monosaccharides – A mixture of D – galactose and D – fructose , using n-butanol , acetone and water (4:5:1); Spray reagent – aniline hydrogen phthalate.

#### *Qualitative analysis:*

Identification of single organic compound through functional group analysis and determination of melting point.

### C. Physical Chemistry :

#### *Transition Temperature:*

1. Determination of the transition temperature of the given substance by thermometric method (e.g. MnCl<sub>2</sub>. 4H<sub>2</sub>O / SrBr<sub>2</sub>. 2H<sub>2</sub>O)

#### *Phase Equilibrium:*

1. To study the phase diagram of phenol water-system and to determine the upper consolute temperature.
2. To study the distribution of iodine between water and CCl<sub>4</sub>.
3. To study the distribution of benzoic acid between benzene and water.

#### *Thermochemistry:*

1. To determine the solubility of benzoic acid at different temperature and hence determine enthalpy of solution.
2. To determine the enthalpy of neutralization of a weak acid / weak base versus strong base / strong acid and determine the enthalpy of ionization of the weak acid / weak base.

***Books Suggested:***

1. Vogel's text book of Quantitative Inorganic Analysis (revised) , J. Bassett, R.C. Denney, G. H Jeffery and J. Mendham (ELBS), 6<sup>th</sup> edn., 2007.
2. Experimental Inorganic Chemistry, W.G. Palmer (Cambridge).
3. Handbook of preparative Inorganic Chemistry, Vol. I & II , Brauer (Academic Press).
4. Experimental Organic Chemistry Vol I & II , P.R. Singh , D.S. Gupta and K.S. Barpal Lata (McGraw Hill)
5. Laboratory manual in Organic Chemistry , R.K. Bansal (Wiley Eastern)
6. Vogel's Textbook of practical Organic Chemistry , B.S. Furniss, A.J. Hannaford, V. Rogers, P.W.G Smith and A.R. Tatchell (ELBS), 5<sup>th</sup> edn., 2009.
7. Experiments in Physical Chemistry , R. C Das and B. Behra (Tata McGraw Hill)
8. Advanced Practical Physical Chemistry , J.B. Yadav (Goel Publishing House), 20<sup>th</sup> edn., 2001.
9. Advanced Experimental Chemistry, Vol. I-Physical , J.N. Gurtu and R. Kapoor (S. Chand & Co), 1<sup>st</sup> edn., 2000.