

# Syllabus of Chemistry (Major & Minor) for 3-Year and 4-Year B.Sc. Course

## Chemistry Major

### Semester-III

Paper Code: **CEMMJ-T5 (Inorganic Chemistry - II)**

(Credit: 03)

Total Lectures: 45

#### 1. Redox Reactions and Precipitation Reactions: (15 L)

Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples). Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides.

#### 2. Chemical Bonding-I: (15 L)

**Ionic bond:** General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born- Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elementary idea). Solubility energetics of dissolution process.

**Covalent bond:** Polarizing power and polarizability, ionic potential, Fajan's rules. Lewis structures, formal charge. Valence Bond Theory. The hydrogen molecule (Heitler-London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, Dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding ( $\sigma$  and  $\pi$  bond approach).

#### 3. Chemical Bonding-II: (15L)

Molecular orbital concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO)) (elementary pictorial approach): sigma and pi-bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing, MO diagrams of  $H_2$ ,  $Li_2$ ,  $Be_2$ ,  $B_2$ ,  $C_2$ ,  $N_2$ ,  $O_2$ ,  $F_2$ , and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO,  $NO^+$ ,  $CN^-$ , HF,  $BeH_2$ ,  $CO_2$  and  $H_2O$ . Bond properties: bond orders, bond lengths.

**Metallic Bond:** Qualitative idea of valence bond and band theories. Semiconductors and insulators.

**Weak Chemical Forces:** van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Intermolecular forces: Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest

interactions, Halogen bonds. Effects of chemical force, melting and boiling points.

**Recommended Text Books and Reference Books:**

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke, Weller, Armstrong; Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010).
3. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008
4. R. Sarkar, General and Inorganic Chemistry Part-I, New Central Book Agency 2014
5. A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rd Edition, Pearson India, 2002
6. J. E. Huheey, E. A. Keiter, R. L. Keiter, Okhil K. Medhi, Principles of Structure and Reactivity, 5th Edition, Pearson India, 2022
7. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 2, Revised Second Edition), CBS Publishers & Distributors Pvt. Ltd.
8. Principles of Inorganic Chemistry (33<sup>rd</sup> Edition), B.R. Puri, L.R. Sharma, K.C. Kalia, Vishal Publishing Co.
9. Inorganic and Solid State Chemistry, G. E. Rodger, Cengage Learning India Edition, 2002.
10. Inorganic Chemistry, Part – I, 7th Edn., R. L. Dutta and G. S. De, The New Book Stall, 2013.

**Paper Code: CEMMJ-P5 (Inorganic Chemistry - II PRAC)**  
**(30 Hours)**

**(Credit: 01)**

**List of Practicals**

**Redox Titration:**

1. Dichromatometric estimation of Fe(II) in Fe(II) salt.
2. Dichromatometric estimation of Fe(III) in ferric alum.
3. Permanganometric estimation of oxalic acid and sodium oxalate in a given mixture.
4. Iodometric estimation of copper in solution of cupric salt.
5. Estimation of vitamin C (reduced L-ascorbic acid) by iodimetry.

**Reference Books:**

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas and B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis (6<sup>th</sup> Edition), Pearson.
2. Chemistry in Laboratory (New Revised Edition), S. Ghosh, M. Das Sarma, D. Majumdar, S. Manna; Santra Publication Pvt. Ltd.
3. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.
4. Advanced Practical Chemistry (3<sup>rd</sup> Edition), S.C. Das.

**Paper Code: CEMMJ-T6 (Physical Chemistry - II)**

**(Credit: 03)**

**Total Lectures: 45**

**1. Thermodynamics II:**

**(15L)**

**Second law and Entropy:** Need for a Second law, Carnot cycle, statement of the second law of thermodynamics, Kelvin –Planck and Clausius statements;; The thermodynamic temperature scale, Carnot cycle with an ideal gas, Efficiency of Carnot engine and Carnot refrigerator; Definition of Entropy (with mathematical formulation) , The Clausius inequality; (T, V) and (T,P) dependence of entropy, Physical concept of Entropy, Entropy change of systems and surroundings for various processes and transformations, Trouton's rule.

**Spontaneity and Equilibrium:** General condition for spontaneity and equilibrium, Conditions for spontaneity and equilibrium under constraints: Helmholtz energy (A), Gibbs free energy (G), their physical significance; Fundamental Equations of thermodynamics and Maxwell's relations, Thermodynamic equation of state and its applications; Properties of A and G, fugacity and fugacity coefficient, Gibbs-Helmholtz equation.

## 2. Application of Thermodynamics I:

(20L)

**Partial properties and Chemical potential:** Changes of thermodynamic state properties with variation of composition, Partial Molar quantities and additivity rule; Gibb's energy of a mixture, Chemical potential of pure ideal gas and mixture of ideal gases, Gibb's energy and entropy of mixing.

**Chemical Equilibrium:** Thermodynamic conditions for equilibrium, Chemical equilibrium in a mixture, degree of advancement; Variation of free energy with degree of advancement ( $\xi$ ), General behaviour of  $G$  as a function of  $\xi$ ; Chemical equilibrium in a mixture of ideal gases, The equilibrium constants,  $K_p$ ,  $K_x$  and  $K_c$ ; Standard Gibbs energy of formation, Temperature dependence of equilibrium constant and Gibbs-Helmholtz equation, Le Chatelier Principle and its derivation; The Gibbs-Duhem equation.

**Nernst's distribution law:** Application- (finding out  $K_{eq}$  using Nernst distribution law for  $KI + I_2 = KI_3$  and dimerization of benzene.

## 3. Surface phenomenon

(10L)

**Surface tension and energy:** Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading of liquid over other surface; Vapour pressure over curved surface; Temperature dependence of surface tension.

**Adsorption:** Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogeneous catalysis (single reactant); Zero order and fractional order reactions.

**Colloids:** Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Determination of Avogadro number by Perrin's method; Stability of colloids and zeta potential; Micelle formation.

### Reference Books:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press. 2. Castellan, G. W. Physical Chemistry, Narosa. 3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press. 5. Levine, I. N. Physical Chemistry, Tata McGraw-Hill. 6. Rakshit, P.C., Physical Chemistry Sarat Book House. 7. Kapoor, K. L., A Text Book of Physical Chemistry, 6<sup>th</sup>Edn, McGraw-Hill.

## Paper Code: CEMMJ-P6 (Physical Chemistry- II PRAC)

(Credit: 01)

### List of Practicals

1. Determination of partition coefficient of benzoic acid between benzene and water.
2. Determination of surface tension of a liquid using Stalagmometer.
3. Determination of CMC from surface tension measurements.

## Paper Code: CEMMJ-SEC-III (Chemistry in Daily Life)

(Credit: 03)

(45 Hours)

### 1. Chemistry in Food and Beverages:

(8L)

**Dairy Products:** Composition of milk and milk products. Analysis of fat content, minerals in milk and butter. Estimation of added water in milk.

**Beverages:** Analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy,

estimation of methyl alcohol in alcoholic beverages.

**Food Additives, Adulterants and Contaminants.** Food preservatives like benzoates, propionates, sorbates, disulphites.

**Artificial Sweeteners:** Aspartame, saccharin, dulcin, sucralose and sodium cyclamate. Flavours: vanillin, alkyl esters (fruit flavours) and monosodium glutamate.

**Artificial Food Colourants:** Coal tar dyes and non-permitted colours and metallic salts. Analysis of pesticide residues in food.

## **2. Fuels: (6L)**

Classification of fuels, octane number, cetane number, flash point, anti-knock compounds, conventional and non-conventional energy sources, calorific values of fuels like kerosene, coal, coal gas, petrol, liquefied petroleum gas, biogas.

## **3. Drugs And Pharmaceuticals: (6L)**

Drugs and their classification. Therapeutic action of different classes of the drugs *viz.* analgesics, antibiotics, antacids, antihistamines, antimicrobials, contraceptives, antipyretics, antiseptics and neurologically active drugs preparation, structure and functions: Aspirin, paracetamol, ibuprofen, sulphadiazine, quinine, phenobarbital, phenacetin and metronidazole.

## **4. Perfumes and Flavors: (8L)**

Classification of perfumes. Perfume ingredients listed as allergens. Deodorants, antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to eugenol, geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, jasmone, civetone, muscone. Volatile oils: Volatile oils of mentha, lemon peel, orange peel, lemon grass, eucalyptus, musk, sandal wood.

## **5. Oils, Fats, Soaps and Detergents: (5L)**

Constituents, mode of action, iodine value, saponification value, hydrogenation of unsaturated oils, production and uses of washing soap, liquid soap and toilet soap, detergent powder and enzyme-based detergent.

## **6. Insecticides: (4L)**

Definition, classification according to the mode of action. Preparation and uses of D.D.T., B.H.C, aldrin, dithion and dithiocarbamate.

## **7. Polymer: (8L)**

Classification, difference between natural and synthetic fibres, manufacture and uses of viscose rayon. Nylon 66 and terylene. Silicone rubber, difference between natural and synthetic rubber, vulcanisation. Manufacture, properties and uses of Buna-S, neoprene, foam rubber and thermocol. Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene).

## **Reference Books:**

1. Analytical Chemistry (Skill Enhancement Course), K. Chattopadhyay, M. Mandal; CBS Publishers & Distributors Pvt. Ltd.
2. Food Science (Seventh Edition), B. Srilakshmi, New Age International Publishers.
3. Dinesh Fuel Chemistry & Chemistry of Cosmetics & Perfumes, S.K. Juneja, A. Kumar, S. Dinesh & Co.
4. Patrick, G. L. Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
5. Industrial Chemistry, B.K. Sharma, GOEL Publishing House.
6. Application Oriented Chemistry, S. Sengupta, Books Syndicate Pvt. Ltd., 2000