

**Structure of Chemistry (major) Syllabus under  
NEP-2020 (Semester I to VI)**

Yr	Sem	Theory Paper		Practical paper			Total Credits
		Paper Code	Units	Paper Code	Units	Project	
1	I	CH101C (Th) Credit: 4	Group –A: Inorganic Group –B: Physical	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH102C (Th) Credit: 2	Group A: Organic	CH102C (Pr) Credit: 2	Group B: Inorg & Org		
	II	CH201C (Th) Credit: 4	Group-A: Organic Group-B: Inorganic	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH202C (Th) Credit: 2	Group –A: Physical	CH202C (Pr) Credit: 2	Group-B: Phys, Org & Inorg		
2	III	CH301C (Th) Credit: 4	Group-A: Organic Group –B: Physical	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH302C (Th) Credit: 2	Group-A: Inorganic	CH302C (Pr) Credit: 2	Group-B: Org & Inorg		
	IV	CH401C (Th) Credit: 4	Group-A: Inorganic Group –B: Physical	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH402C (Th) Credit: 2	Group A: Organic	CH402C (Pr) Credit: 2	Group-B: Phys & Green Chem		
3	V	CH501C (Th) Credit: 4	Group-A: Inorganic Group –B: Organic	Nil	NA	Nil	12(Theory) 4 (Practical)
		CH502C (Th) Credit: 2	Group –A: Physical	CH502C(Pr) Credit: 2	Group-B: Phys Practical		
		CH503C (Th) Credit: 4	Group-A: Inorganic Group-B: Physical	Nil	NA		
		CH504C (Th) Credit: 2	.Group-A: Organic	CH504C (Pr) Credit: 2	Group-B: Org Chem Pract		
	VI	CH601C (Th) Credit: 4	Group-A: Organic Group-B: Physical	Nil	NA	Nil	12(Theory) 4 (Practical)
		CH602C(Th) Credit: 2	Group A: Inorganic	CH602C(Pr) Credit: 2	Group B: Inorg Chem Pract		
		CH603C (Th) Credit: 4	Group A : Environ & Green Chemistry Group B: Analytical Method in Chemistry	Nil	NA		
		CH604C (Th) Credit: 2	Group A: Industrial Chemistry	CH604C (Pr) Credit: 2	Group B: Industrial Chem		
<b>Total</b>	<b>16 Papers</b>					<b>Total 64 48(Theory) 16 (Practical)</b>	

Major

**SEMESTER-I**

**Paper Code: CH101C (Th)**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-1**

**Group-A: Inorganic Chemistry, 02 Credits, Marks: 50**

**UNIT- I: Atomic Structure**

**(15 L× 45 minutes)**

Bohr's atomic model, Bohr-Sommerfeld model, their limitations, photo electric effect, de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation (1 electron system). Normalized and orthogonal wave functions, significance of  $\psi$  and  $\psi^2$ . Radial and angular wave functions and distribution curves (H-atom). Quantum numbers and their significance, shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, variation of atomic orbital energy

**UNIT- II: Periodic Properties**

**(15 L× 45 minutes)**

Periodic classification of elements; Classification of elements on the basis of electronic configuration, discussion of the following properties of the elements, effective nuclear charge, shielding or screening effect, Slater's rule, variation of effective nuclear charge, Atomic radii (van der Waals), ionic radii, covalent radii, ionization enthalpy, successive ionization enthalpies and factors affecting ionization energy, applications of ionization enthalpy, electron gain enthalpy, trends of electron gain enthalpy, electronegativity, Pauling's/ Mulliken's/ Allred Rachow's electronegativity scales, group electronegativity, diagonal relationship.

**Theoretical Principles in Qualitative Analysis**

Basic principles involved in analysis of cations and anions and solubility, solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents.

**Group –B: Physical Chemistry, 02 Credits, Marks: 50**

**UNIT-I: Kinetic Theory of Gas**

**(15 L× 45 minutes)**

Postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of Equipartition of energy, degrees of freedom Heat capacities of gas.

Deviations from ideal gas behaviour, compressibility factor, Z, Causes of deviation from ideal behaviour. van der Waals equation of state, Isotherms of real gases and their comparison with van der Waals isotherms, Boyle Temperature, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

**UNIT-II: Thermodynamics-I**

**(15 L× 45 minutes)**

First law: Concept of heat (q) work (w) internal energy (U) and statement of first law; enthalpy (H); relation between heat capacities, adiabatic relations, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Relationship between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature.

**Thermochemistry:** Hess's Law, Heats of reactions: standard states; enthalpy of formation of molecules and ions, enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy, enthalpy of neutralization, enthalpy of solution and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

**Recommended Books:**

1. J.D. Lee, *Concise Inorganic Chemistry*, 5<sup>th</sup> Edition (ELBS)
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4<sup>th</sup> Edition (Pearson Education)
3. K Das, *Fundamental Concepts of Inorganic Chemistry*, Vol.1-4 (CBS Publishers & Distributors)
4. S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, *Advanced Inorganic Chemistry*, Vol. 1-2 (S Chand & Co Ltd)
5. Malik, Tuli, Madan, *Selected Topics in Inorganic Chemistry*, Revised Edition (S Chand & Co Ltd)
6. S. P. Banerjee, *Advanced Inorganic Chemistry*, 2<sup>nd</sup> Edition (Books & Allied (P) Ltd)
7. R. L. Dutta, *Inorganic Chemistry Vol-1 & 2* (New Book Stall)
8. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)
9. R. Sarkar, *General and Inorganic Chemistry (Part I & II)*, New Central Book Agency Ltd.
10. P. C Rakhit, . *Physical Chemistry*, 7th edition
11. P. W. Atkins & Paula, J. de Atkin' *Physical Chemistry Ed.*, Oxford University Press 13(2006).
12. D. W. Ball, *Physical Chemistry Thomson Press, India* (2007).
13. A. S. Negi, S. C. Anand, *Text book of Physical Chemistry*
14. G. W. Castellan, *Physical Chemistry 4th Ed. Narosa* (2004).
15. M. J Assael, A. R. H, Goodwin, M. Stamatoudis, W. A. Wakeham, & S. Will, *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011).
16. C.R. Metz, *2000 solved problems in Chemistry, Schaum Series* (2006).

**SEMESTER-I**

**Paper Code: CH102C (Th+ Pr)**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-2**

**Major**

**Group-A: Organic Chemistry, 02 Credits, Marks: 50**

**UNIT- I: Structure, bonding & Fundamentals of Organic reactions (15 L× 45 minutes)**

**General Introduction:** Organic compounds and their classification, nomenclature (trivial and IUPAC), molecular formula, double bond equivalent (DBE), idea of framing constitution from molecular formula.

**Bonding Features:** Nature of bonds and its orbital representation, atomic and molecular orbitals - bonding, nonbonding and anti-bonding, hybridization ( $sp^3$ ,  $sp^2$ ,  $sp$ ) of C,N,O and halogens; bond lengths, bond angles, bond energy, bond polarity, bond polarizability, formation of  $\sigma$  and  $\pi$  bonds, localized and delocalized chemical bonds, van der Waals interaction, conjugation (resonance), resonance energy, steric inhibition of resonance, hyperconjugation, inductive and field effects, tautomerism, H-bonding, dipole moment- bond moment and group moment, physical properties (mp, bp, solubility) related to molecular structures.

**Fundamentals of Organic Reactions:** Energy of bond cleavage and bond formation, homolytic and heterolytic bond cleavages. Structure, stability, formation and reactions of electrophiles, nucleophiles and free radicals. Reaction intermediates: carbocations, carbanions, carbenes (electrophilic and

nucleophilic), arynes, free radicals and nitrenes. Study of a) Electrophilic and free radical addition at C=C, b) Nucleophilic addition at the C=O group of aldehydes and ketones; c) Nucleophilic substitution reactions -  $S_N^1$ ,  $S_N^2$ ,  $S_N^i$ ; d) Electrophilic substitution in the aromatic system; Elimination reactions -  $\alpha$  and  $\beta$ -eliminations, *syn* - and *anti*-elimination;  $E_1$  and  $E_2$ - mechanism.

## UNIT- II: Stereochemistry of Organic Compounds:

(15 L × 45 minutes)

**Stereoisomerism:** Different types of stereoisomerism; conformation and configuration. Optical isomerism-optical activity, specific rotation and specific rotation of mixtures, asymmetry and dissymmetry, chirality, elements of symmetry, enantiomers and diastereomers, threo, erythro and meso compounds, representation of molecules in Fischer, flying-wedge, Sawhorse and Newman formulae and their inter conversion. Resolution of racemic mixture, racemisation, asymmetric synthesis-Cram's rule and Prelog's rule. Relative and absolute configurations, sequence rules, D/L and R/S systems of nomenclature. Geometrical isomerism-determination of configuration of geometrical isomers; E/Z and *syn/anti* nomenclature, geometrical isomerism in oximes and alicyclic compounds.

**Conformation:** Conformational nomenclature; eclipsed, staggered, gauche and anti; dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effects, conformational analysis of ethane, n-butane.

### Group-B: Practical, Credit: 02, Marks: 50

#### **Inorganic Qualitative analysis**

Qualitative analysis of mixtures of inorganic salts containing not more than **three** radicals (**water soluble**) from the following lists. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:  $NO_2^-$ ,  $SO_4^{2-}$ ,  $Cl^-$ ,  $Br^-$ ,  $I^-$ ,  $NO_3^-$ ,  $NH_4^+$ ,  $K^+$ ,  $Pb^{2+}$ ,  $Cu^{2+}$ ,  $Cd^{2+}$ ,  $Sn^{2+}$ ,  $Bi^{3+}$ ,  $Sb^{3+}$ ,  $Fe^{3+}$ ,  $Cr^{3+}$ ,  $Al^{3+}$ ,  $Zn^{2+}$ ,  $Mn^{2+}$ ,  $Ni^{2+}$ ,  $Co^{2+}$ ,  $Ba^{2+}$ ,  $Sr^{2+}$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ . **Spot tests as well as green methods may be followed if possible.**

#### **Organic Qualitative analysis**

Identification of special elements (nitrogen, sulphur, halogens) and functional groups viz.  $>C=C<$ , phenolic-OH, -COOH, -CHO,  $>CO$ ,  $-NH_2$ ,  $-CONH_2$ ,  $-NO_2$ , in a pure solid organic compound.

#### **Recommended Books:**

1. Sachin Kumar Ghosh, *Advance General Organic Chemistry, A Modern Approach, Part-I & II*, NCBA
2. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*; Wiley: London, 1994.
6. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*; New Age International, 2005.
7. Vogel's *Qualitative Inorganic Analysis*, Revised by G. Shelva, 7<sup>th</sup> Edition (Prentice Hall)
8. Ghoshal, Mahapatra, Nad, *An advanced course in Practical Chemistry* (NCBA)
9. S. C. Das, *Advanced Practical Chemistry*, The World Press Private Limited
10. *Qualitative Organic Analysis, CHE-08L, Chemistry Lab-III*, IGNOU
11. N.K. Vishnoi, *Advanced Practical Organic Chemistry*, Vikas Publishing House
12. M. M. Nandi, *Essentials of Chemistry* (New Age International)
13. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)

Major

SEMESTER-II

Paper Code: CH201C (Th)  
Credit: 04, Total Marks: 100  
Name of Paper: Chemistry-3

**Group-A: Organic Chemistry, 02 Credits, Marks: 50**

**UNIT-I: Aliphatic Compounds -I**

**(15 Lx 45 minutes)**

**Alkanes, alkenes and alkynes:** Synthesis of alkanes; Synthesis and properties of alkenes, alkynes and alkadienes. Inter conversion of constitutional isomers of alkenes and alkynes; inter conversion of E & Z isomers of alkenes.

**Reactions with mechanism:** Markownikoff's addition to alkenes, peroxide effects, ozonolysis, hydroboration-oxidation, oxy-mercuration-demercuration of alkenes, electrophilic and free radical addition to conjugated dienes; 1,2 Vs 1,4- additions; Birch reduction of alkadienes and alkynes; catalytic hydrogenation of alkenes and alkynes; use of Lindler catalyst.

**UNIT-II: Alicyclic compounds:**

**(15 Lx 45 minutes)**

**Alicyclic compounds:** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

**Alkyl halides:** Methods of preparation, nucleophilic substitution reactions – S<sub>N</sub>1, S<sub>N</sub>2 and S<sub>N</sub>i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

**Alcohols:** Preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, distinguish 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

**Ethers and Epoxides:** Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH<sub>4</sub>.

**Group-B: Inorganic Chemistry, 02 Credits, Marks: 50**

**UNIT-I : Chemical bonding-I**

**(15 Lx 45 minutes)**

**Ionic bond:** General characteristics, radius ratio rule and its limitations. Born-Landé equation with derivation, Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application. Solvation energy, solubility of ionic solids, ionic potential. Covalent character in ionic compounds: polarizing power, polarizability of ions, partial charge, Fajan's rule and consequences.

**Covalent bond:** General Characteristics, Resonance and resonance energy, Valence Bond theory (Heitler-London approach), Concept of hybridization, hybrid orbitals using s, p and d orbitals, equivalent and non-equivalent hybrid orbitals, energetic of hybridization, Formal charge. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$  and  $\pi$  bond approach). Bent's rule.

**UNIT-II**

**(15 Lx 45 minutes)**

**Acid-Base Concepts:** Arrhenius and Bronsted-Lowry concept, the Solvent-System concept (Franklin) and their limitations; Lewis concept; SHAB principle, Application of SHAB principle; relative

strengths of acids and bases ( $pK_a$  and  $pK_b$  concept), leveling effect; pH and pH scale, acid-base indicators.

### **Statistical Data Analysis:**

Types of errors, Accuracy and Precision, Standard Deviation, Rejection of Data: F-test, Q-test and t-test.

### **Recommended Books:**

1. S.N. Sanyal, *Reactions, Rearrangements and Reagents*, Bharati Bhawan
2. Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
3. Richard O.C. Norman, James M. Coxon, *Principles of Organic Synthesis*, CRC Press
4. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. T. W. Graham Solomons: *Organic Chemistry*, John Wiley and Sons.
7. Sachin Kumar Ghosh, *Advance General Organic Chemistry, A Modern Approach, Part-I & II*, NCBA
8. J.D. Lee, *Concise Inorganic Chemistry*, 5<sup>th</sup> Edition (ELBS)
9. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4<sup>th</sup> Edition (Pearson Education)
10. S. K. Basu, R. D. Madan, Satya Prakash and G. D. Tuli, *Advanced Inorganic Chemistry – Vol. 1-2* (S Chand & Co Ltd)
11. Malik, Tuli, Madan, *Selected Topics in Inorganic Chemistry*, Revised Edition, (S Chand & Co Ltd)
12. S. P. Banerjee, *Advanced Inorganic Chemistry*, 2<sup>nd</sup> Edition (Books & Allied (P) Ltd)
13. R. L. Dutta, *Inorganic Chemistry Vol-1 & 2* (New Book Stall)
14. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)
15. Hibbert, D. B. & Gooding, J. J, *Data analysis for chemistry* (Oxford University Press, 2006)

## **SEMESTER-II**

**Paper Code: CH202C (Th + Pr)**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-4**

**Major**

### **Group –A: Physical Chemistry, 02 Credits, Marks: 50**

#### **UNIT-I: Colligative Properties of solutions**

**(15 L × 45 minutes)**

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 using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure. Inter relationship between different colligative properties, Abnormal molar mass, Van't Hoff factor, Colligative properties of degree of dissociation and association of solutes.

#### **UNIT-II:**

**(15 L × 45 minutes)**

**Solid States:** Unit cell and Space lattice, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative

idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Laue equation, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Structure of Different Ionic Crystal (NaCl, CsCl and KCl.) Different Stoichiometric & nonstoichiometric defects in crystals. Electrical and magnetic properties of solid.& Superconductivity.

**Liquid States:** surface tension, Surface energy, Contact angle, Determination of surface tension, derivations of coefficient of viscosity, and their determination. Effect of temperature on surface tension, Applications of Surface tension, Viscosity & Viscosity coefficient, Measurement of viscosity, Effect of addition of various solutes on surface tension and viscosity. Temperature variation on viscosity of liquids, Qualitative discussion of structure of Liquid.

**Group –B: Practical, 02 Credits, (01+01), Marks: 50**

**A. Physical Chemistry: Surface tension and Viscosity measurements**

1. Determine the surface tension by drop number method
2. Study the variation of surface tension of detergent solutions with concentration.
3. Determination of concentration of a given solution by measuring the surface tension of the solution.
4. Determination of Coefficient of viscosity of given liquid/solution by Ostwald Viscometer at room temperature.
5. Determination of concentration of a given solution by measuring the viscosity of the solution.

**B. Organic quantitative analysis**

1. Estimation of aniline using brominating mixture
2. Estimation of Oxalic acid by standardized NaOH
3. Estimation of vinegar by using standardized NaOH
4. Estimation of glycine by formal titration method (Soronsen's Method)

**C. Inorganic Quantitative analysis:**

1. Oxidation-Reduction Titrations
  - a. Estimation of Fe(II)/Fe(III) by  $\text{KMnO}_4$  solution.
  - b. Estimation of Fe(II)/Fe(III) by  $\text{K}_2\text{Cr}_2\text{O}_7$  solution
2. Iodometric Titrations
  - a. Estimation of Cu(II) by sodium thiosulphate solution.

**Recommended Books:**

1. P. W. Atkins, & Paula, J. de Atkin' *Physical Chemistry Ed.*, Oxford University Press 13(2006).
2. D. W. Ball, *Physical Chemistry Thomson Press, India (2007)*.
3. G. W. Castellan, *Physical Chemistry 4th Ed. Narosa (2004)*.
- A. S. Negi, S. C. Anand, *A Textbook of Physical Chemistry*
4. P.C. Rakhit. *Physical Chemistry, 7th edition*
- A. Peter, & J. de. Paula, *Physical Chemistry 10th Ed.*, Oxford University Press (2014).
5. T. Engel, & P. Reid, *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
6. D. A. McQuarrie, & J. D. Simon, *Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004)*.
7. I.N. Levine, *Physical Chemistry 6th Ed.*, Tata Mc Graw Hill (2010).
8. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis, 6<sup>th</sup> Edition (Pearson)*
9. S. C. Das, *Advanced Practical Chemistry, 3<sup>rd</sup> Edition, The World Press Private Limited*

10. G N Mukherjee, *Advanced Experiments in Inorganic Chemistry* (U. N. Dhur & Sons Pvt. Ltd)  
11. N. K. Vishnoi, *Advanced Practical Organic Chemistry*, Vikas Publishing House  
12. *Chemistry Lab-V, CHE-12L, IGNOU*  
13. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.

**Major**

**SEMESTER-III**  
**Paper Code: CH301C (Th)**  
**Credit: 04, Total Marks: 100**  
**Name of Paper: Chemistry-5**

**Group –A: Organic Chemistry, 02 Credits, Marks: 50**

**UNIT-I : Aliphatic Compounds - II (15 L× 45 minutes)**

**Carbonyl Compounds:** Structure, reactivity & preparation: Nucleophilic addition – eliminations of ammonia derivatives with mechanism; mechanisms of Aldol and benzoin Condensation, Knoevenagel condensation, Claisen Schmidt, Cannizzaro, Tischenko reactions, Wittig reaction, Benzil-benzilic acid rearrangement, haloform reaction, Baeyer Villiger Oxidation, Alpha Substitution reactions, Oxidations and Reductions (Clemmensen, Wolff Kishner). Addition reactions of unsaturated carbonyl compounds; Michael addition.

**Carboxylic Acids and their Derivatives:** Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Hoffmann Bromamide Reaction.

**UNIT- II: Aromatic Compounds (15 L× 45 minutes)**

**Aromatic hydrocarbon and aromaticity:** Sources, nomenclature and isomerisation of aromatic compounds, structure of benzene, stability of benzene ring, molecular orbital picture of benzene, aromaticity, Huckel's (4n+2) rule and its simple applications. Electrophilic substitution reactions in aromatic compounds. General mechanism of aromatic electrophilic substitution, effect of substituent groups, directive influence, orientation, isotope effect, nitration, sulphonation, halogenation, Friedel-Craft's alkylation and acylation, energy profile diagram, nuclear and side chain halogenation.

**Aromatic halogen compounds:** Introduction, method of synthesis, physical properties, chemical reactivity, nucleophilic aromatic substitution and its mechanism.

**Aromatic compounds containing nitrogen:** Introduction, methods of synthesis and physical properties, mechanism of nitration, reduction products of nitro compounds. Introduction, methods of synthesis of aromatic amines, basicity and effect of substituents, chemical reactivity. Diazotization and reactions of diazonium salts.

**Phenols:** Synthesis, physical properties, acidic character, chemical reactions, Kolbe reaction, Reimer – Tiemann reaction, Fries rearrangement, Claisen rearrangement. Houben – Hoesch reaction, phenol – formaldehyde resin, cresols, nitro and amino phenols, dihydric and trihydric phenols.

**Aromatic alcohols, aldehydes, ketones:** Introduction, methods of synthesis, physical properties, chemical reactivity of aromatic alcohols, aldehydes and ketones, Perkin reaction, phenolic aldehydes.



**Group –B: Physical Chemistry, Credit 2, Marks: 50**

**UNIT-I: Equilibrium**

**(15 L× 45 minutes)**

**Chemical Equilibrium:** Law of mass action, thermodynamic derivation of law of mass action. Equilibrium constant & its significance, Van't Hoff equation, Van't Hoff reaction isochore, calculations of  $\Delta G^0$ ,  $\Delta H^0$  &  $\Delta S^0$  from equilibrium constant, factors influencing an equilibrium state, Le-Chatelier's principle, its application in different chemical & physical equilibrium.

**Ionic Equilibrium:** Ionization of weak acids and bases, pH scale, Calculation of pH, Use of pH, dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

**UNIT-II: Thermodynamics-II**

**(15 L× 45 minutes)**

Need of Second Law of Thermodynamics, Second Law, Carnot Theorem, Application of Carnot cycle, Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Feature of Entropy Change, Calculations of entropy change for reversible and irreversible processes, during phase change. Entropy & probability. Variation of S, G, A with T, V, P; Free energy change and spontaneity. Gibbs and Helmholtz energy; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. Third Law: Statement of third law, Nernst Heat theorem, concept of residual entropy, calculation of absolute entropy of molecules.

**Recommended Books:**

1. R. N Morrison, & R. N. Boyd, *Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Edu)*.
2. I. L. Finar, *Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)*.
3. Sachin Kumar Ghosh, *Advance General Organic Chemistry, A Modern Approach, Part-I & II, NCBA*
4. Subrata Sengupta, *Organic Chemistry, Book Syndicate PVT. LTD*
5. P. W. Atkins, & Paula, J. de Atkin' *Physical Chemistry Ed., Oxford University Press 13(2006)*.
6. D. W. Ball, *Physical Chemistry Thomson Press, India (2007)*
7. G. W. Castellan, *Physical Chemistry 4th Ed. Narosa (2004)*.
8. A. S. Negi, S. C Anand, *A Textbook of Physical Chemistry*
8. P. C. Rakhit. *Physical Chemistry, 7<sup>th</sup> edition*

**SEMESTER-III**

**Major**

**Paper Code: CH302C (Th + Pr)**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-6**

**Group –A: Inorganic Chemistry, 02 Credits, Marks: 50**

**UNIT- Chemical Bonding-II**

**(15 L× 45 minutes)**

a) **MOT:** Molecular orbital theory, Molecular orbital diagrams of diatomic and simple polyatomic molecules  $N_2$ ,  $O_2$ ,  $C_2$ ,  $B_2$ ,  $F_2$ , CO, NO and their ions; HF,  $BeF_2$ ,  $BeCl_2$  (idea of s-p mixing and orbital interactions).

**b) Weak Chemical Forces:** Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Ionic character in covalent compounds: Bond moment and dipole moment, percentage ionic character. Repulsive forces, Hydrogen bonding, significance and effect on structure of compounds.

**c) Metallic Bond:** Qualitative idea of valence bond and band theories. Conductors, semiconductors and insulators, defects in solids.

## **UNIT-II: Coordination Chemistry-I**

**(15 L × 45 minutes)**

Introduction of Coordination compound, classification of ligands, coordination number and stereochemistry, IUPAC nomenclature of coordination compounds, Werner's coordination theory, chelation, chelate effect and its application, isomerism in coordination compounds, stereochemistry of complexes with 4 and 6 coordination numbers, innermetallic complexes and their applications in Analytical Chemistry.

### **Bonding in coordination compounds:**

(a) EAN rule (Sidwick concept)

(b) Valence bond theory (inner and outer orbital complexes), low spin, high spin complexes, explanation of magnetic moment of coordination compounds and imitations of VBT.

**Magnetism:** Types, electron spin angular moment and orbital angular moment, magnetic susceptibility and magnetic moment; Curie law, Curie-Weiss law, explanation of magnetic behaviour of coordination compounds taking examples of  $[\text{Co}(\text{NH}_3)_6]^{3+}$ ,  $[\text{Fe}(\text{CN})_6]^{4-}$ ,  $[\text{Fe}(\text{CN})_6]^{3-}$ ,  $[\text{FeF}_6]^{3-}$ ,  $[\text{CoF}_6]^{3-}$ ,  $[\text{Ni}(\text{CN})_4]^{2-}$ ,  $[\text{NiCl}_4]^{2-}$ ,  $[\text{Mn}(\text{NH}_3)_6]^{2+}$

### **Group –B: Practical, 02 Credits (01+01), Marks: 50**

**Organic Compound Preparation:** List of compounds to be prepared in pure state is:

Phthalimide, Benzil, Iodoform, Benzilic acid

(Any of the above compounds is to be set in the examination)

### **Preparation of the following coordination compounds:**

Tris(thiourea)copper(I)sulphate, Tetra ammine copper(II) sulphate, Potash alum/ Chrome alum  
Bis(dimethylglyoximinato)nickel(II), Tris(acetylacetonato)iron(III), Potassium tri(oxalato)chromate (III)

### **Recommended Books:**

1. J.D. Lee, *Concise Inorganic Chemistry*, 5<sup>th</sup> Edition (ELBS)
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4<sup>th</sup> Edition (Pearson Education)
3. S. K. Basu, R. D. Madan, Satya Prakash and G. D. Tuli, *Advanced Inorganic Chemistry – Vol. 1-2* (S Chand & Co Ltd)
4. S. P. Banerjee, *Advanced Inorganic Chemistry*, 2<sup>nd</sup> Edition (Books & Allied (P) Ltd)
5. R. L. Dutta, *Inorganic Chemistry Vol-1 & 2* (New Book Stall)
6. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)
7. Malik, Tuli, Madan, *Selected Topics in Inorganic Chemistry, Revised Edition*, (S Chand & Co Ltd)
8. B.R. Puri, L.R. Sharma, Kalia, Kaushal, S & P-block elements, *Transition Metals & Co-Ordination Chemistry*(Vishal Publishing Co.)
9. Shriver and Atkins, *Inorganic Chemistry*, 5<sup>th</sup> Edition, (Oxford University Press)
10. Sharpe, *Inorganic Chemistry*, 3<sup>rd</sup> Edition (Pearson Education)
11. R. L. Dutta and A Shyamal, *Elements of Magneto chemistry*, 2<sup>nd</sup> Edition (Affiliated East-West Press)
12. R. Sarkar, *General and Inorganic Chemistry (Part I & II)* < New Central Book Agency Ltd
13. S. C. Das, *Advanced Practical Chemistry*, 3<sup>rd</sup> Edition (Kolkata S.C, Das)

14. G. N. Mukherjee, *Advanced Experiments in Inorganic Chemistry* (U. N. Dhur & Sons Pvt. Ltd)  
15. M. M. Nandi, *Essentials of Chemistry*, New Age International Publication  
16. R.K. Sharma, Indu Tucker Sidhwani & Mihir K. Chaudhuri, *Green Chemistry Experiments*  
17. N.K. Vishnoi, *Advanced Practical Organic Chemistry*, Vikas Publishing House  
18.

#### SEMESTER-IV

Major

Paper Code: CH401C (Th)  
Credit: 04, Total Marks: 100  
Name of Paper: Chemistry-7

#### Group –A: Inorganic Chemistry, 02 Credit, Marks: 50

##### UNIT-I: Coordination Chemistry-II (15 L× 45 minutes)

Crystal field theory, splitting of d-orbitals in octahedral, tetrahedral and square planar complexes, crystal field splitting parameter ( $\Delta$ ), weak and strong field ligands, pairing energy and CFSE, factors affecting the magnitude of  $\Delta$ , spectrochemical series. Explanation of magnetic and optical properties of coordination complexes on the basis of CFT.

Tetragonal distortions, Jahn-Teller distortion. Elementary idea of Ligand Field Theory, nephelauxetic effect. Stability of metal complexes-Thermodynamic and Kinetic stability of complexes.

##### UNIT-II: Redox Reactions (15 L× 45 minutes)

Balancing of redox reactions by Ion electron method, calculation of equivalent weights of oxidants & reductants. Standard electrode potential, formal potential, electrochemical series and their application. Redox indicators and their choice in redox titrations. Importance of redox potential in volumetric analysis.

##### S-block elements:

(i) Group discussion of the elements with respect to position in the periodic table: electronic configuration, atomic and ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy), electronegativity, oxidation states, variation in properties of oxides and hydroxide, solvation and complexation tendencies of alkali and alkaline earth metals.

(ii) Synthesis, structure and properties, uses of Lithium aluminium hydride, sodium thiosulphate, lithopone, potassium iodide, basic beryllium acetate, calcium cyanamide.

#### Group –B: Physical Chemistry, 02 Credit, Marks: 50

##### UNIT-I: Chemical Kinetics (15 L× 45 minutes)

Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristic of simple chemical reactions – zero order, first order, second order, pseudo order, half-life and mean life. Determination of the order of reaction – differential method, method of integration, half-life method and isolation method. Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Theories of reaction rates, Simple collision theory based on hard sphere model, transition state theory for bi molecular reactions, kinetics of parallel reactions, consecutive reactions, reversible reactions & chain reactions.

**UNIT-II: Surface chemistry****(15 Lx 45 minutes)**

**Adsorption:** Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogenous catalysis (single reactant);

**Colloids:** Classifications of Coloids, Lyophobic and lyophilic sols, preparation & purifications of colloids, Origin of charge and stability of lyophobic colloids, properties of colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Stability of colloids and zeta potential; Micelle formation, Gold Number, Iso-electric point, Emulsion, Types and properties of emulsion, Gels, Classification and properties of Gels. Applications of colloid.

**Catalysis:** Characteristics of catalysis, theory of catalysis, acid-base catalysis, enzyme catalysis, kinetics of enzyme catalysis (Michaelis –Menten equation).

**Recommended Books:**

1. J.D. Lee, *Concise Inorganic Chemistry*, 5<sup>th</sup> Edition (ELBS)
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4<sup>th</sup> Edition (Pearson Education)
3. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)
4. F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, *Advanced Inorganic Chemistry, An Indian Adaptation*, (WileyIndia Pvt. Ltd)
5. Malik, Tuli, Madan, *Selected Topics in Inorganic Chemistry*, Revised Edition, (S Chand & Co Ltd)
6. R. L. Dutta, *Inorganic Chemistry Vol-1 & 2* (New Book Stall)
7. S. P. Banerjee, *Advanced Inorganic Chemistry*, 2<sup>nd</sup> Edition (Books & Allied (P) Ltd)
8. B. C. Ray and S. N. Das, *General and Inorganic Chemistry*, 1<sup>st</sup> Edition (NCBA)
9. B.R. Puri, L.R. Sharma, Kalia, Kaushal, S&P-block elements, *Transition Metals & Co-ordination Chemistry*(Vishal Publishing Co.)
10. S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, *Advanced Inorganic Chemistry – Vol. 1-2* (S Chand & Co Ltd)
11. R. D. Madan, *Mordern Inorganic Chemistry*(S Chand & Co Ltd)
12. A. K. Das, *Fundamental Concepts of Inorganic Chemistry*, Vol.1-4 (CBS Publishers & Distributors)
13. R. Sarkar, *General & Inorganic Chemistry, Part-II* (Vol. I & II) (New Central Agency)
14. Peter Atkins & Julio De Paula, *Physical Chemistry 10th Ed.*, Oxford University Press (2014).
15. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
16. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
17. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
18. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011).
19. Zundhal, S.S. *Chemistry concepts and applications Cengage India* (2011).
20. Ball, D. W. *Physical Chemistry Cengage India* (2012).
21. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
22. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill (2011).
23. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).
24. P.C.Rakhit, *A Textbook of Physical Chemistry. Volume 3*.

Major

SEMESTER-IV  
Paper Code: CH402C (Th + Pr)  
Credit: 04, Total Marks: 100  
Name of Paper: Chemistry-8

**Group –A: Organic Chemistry, 02 Credits, Marks: 50**

**UNIT – I: Nitrogen Containing compounds**

**(15 L× 45 minutes)**

Preparation and important reactions of nitro, nitriles and isonitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction and separation between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

**Heterocyclic Compounds:**

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

**UNIT-II: Polynuclear aromatic hydrocarbons**

**(15 L× 45 minutes)**

Polynuclear aromatic hydrocarbons (naphthalene, anthracene, phenanthrene); Aromatic heterocycles with one heteroatom: Introduction, five and six membered heterocycles, aromatic characteristic of heterocyclic compounds, structure, synthesis and reactions of furan, thiophene, pyrrole and pyridine, basicity of pyridine and piperidine.

**Quinones:** Benzoquinones and naphthoquinones – preparations, properties, structures and reactions

**Group –B: Practical, 02 Credits, Marks: 50**

**Physical Chemistry Practical**

1. Determination of rate constant of hydrolysis of ester by HCl/NaOH at room temperature.
2. Study of kinetics of saponification of ethyl acetate and determination of rate constant.
3. To determine the specific reaction rates of hydrolysis of ethyl/methyl ester catalyzed by hydrogen ion at room temperature.
4. To study the effect of acid strength on hydrolysis of ester
5. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

**Green Chemistry**

1. Preparation of acetanilide by using AcOH
2. Bromination of acetanilide using green approach (Bromate-bromide method).
3. Nitration of salicylic acid by green approach (using ceric ammonium nitrate)
4. Synthesis of azomethines from vanillin and 4-amino toluene
5. Preparation of Tris(acetylacetonato)manganese(III) by green method
6. Preparation of Tris(acetylacetonato)iron(III) by green method
7. Preparation of bis(acetylacetonato)copper(II) by green method

### **Recommended Books:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons (1976).
5. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
9. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).
10. B. D.Khosla, V. C. Garg & A. Gulati, *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
11. C. W.Garland, J. W. Nibler, & D. P. Shoemaker, *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
12. A. M.Halpern, & G. C. McBane, *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).
13. *Green Chemistry Task Force Committee, DST, Monograph on Green Chemistry Laboratory Experiments*
14. *Green Chemistry Experiments*, Rakesh K. Sharma, Indu Tucker Sidhwani & Mihir K. Chaudhuri, Tucker Prakashan

### **SEMESTER-V**

**Paper Code: CH501C (Th)**

**Credit: 04, Total Marks: 100**

**Major**

**Name of Paper: Chemistry-9**

### **Group –A: Inorganic Chemistry, 02 Credits, Marks: 50**

#### **UNIT-I: P-block elements & Noble gases**

**(15 L× 45 minutes)**

- i) Group discussion of the elements with respect to position in the periodic table: electronic configuration, atomic and ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy), electronegativity, oxidation states, variation of acidic and basic properties of their oxides and oxy-acids, inert pair effect, Catenation.
- ii) Synthesis, structure and properties of diborane, borazine, silicone, carbides; oxoacids of phosphorus, sulphur and chlorine; Interhalogen compounds, Pseudo-halogens, polyhalides, basic properties of Iodine.
- iii) Occurrence, isolation and uses, rationalization of inertness of noble gases, Clathrates; Synthesis, structure and reactions of xenon oxides, fluorides and oxifluorides.

#### **UNIT-II: Radioactivity and Nuclear Chemistry**

**(15 L× 45 minutes)**

Stability of nucleus and nuclear forces; nuclear binding energy; mass defect and packing fraction; natural and artificial radioactivity; first order rate equation of radioactive disintegration; radioactive equilibrium; radioactive disintegration series; half-life, average life period, group displacement law, unit of radioactivity; carbon-14 dating, types of nuclear reactions, concepts of fusion and fission, Q value.

## Group –B: Organic Chemistry, 02 Credits, Marks: 50

### UNIT-I: Chemistry of Biomolecules- I

(15 L× 45 minutes)

**Carbohydrates:** Introduction, occurrence, classification, nomenclature, inter-relationship amongst monosaccharides, constitution of glucose and fructose, ribose and arabinose, reactions of glucose and fructose, osazone formation, mutarotation and its mechanism, cyclic structures, pyranose and furanose forms, determination of ring size. Haworth projection formula, configurations and conformational analysis of monosaccharides, epimerisation, ascending and descending of sugars, inter conversion of aldoses and ketoses.

**Introduction to disaccharides:** maltose, lactose and sucrose. Introduction to polysaccharides – starch and cellulose.

**Amino Acids, Peptides and Proteins:** Amino acids, Peptides and their classification.  $\alpha$ -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions,  $pK_a$  values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

### UNIT-II: Chemistry of Biomolecules–II

(15 L× 45 minutes)

**Nucleic Acids:** Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

**Enzymes:** Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

**Lipids:** Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number, reversion and rancidity.

### Recommended Books:

1. J.D. Lee, *Concise Inorganic Chemistry*, 5<sup>th</sup> Edition (ELBS)
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4<sup>th</sup> Edition (Pearson Education)
3. S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, *Advanced Inorganic Chemistry – Vol. 1-2* (S Chand & Co Ltd)
4. R L Dutta, *Inorganic Chemistry Vol-1 & 2* (New Book Stall)
5. B.R. Puri, L.R. Sharma, Kalia, Kaushal, S & P-block elements, *Transition Metals & Co-Ordination Chemistry*(Vishal Publishing Co.)
6. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)
7. Malik, Tuli, Madan, *Selected Topics in Inorganic Chemistry, Revised Edition*, (S Chand & Co Ltd)
8. Puri, Sharma Kalia and Kaushal, *A Text Book of Inorganic Chemistry* (Vishal Publishing Co.)
9. Shriver and Atkins, *Inorganic Chemistry*, 5<sup>th</sup> Edition, (Oxford University Press)
10. H. J. Arnikaar and N. S. Rajurkar, *Nuclear Chemistry* (New Age Int. Publishers)
11. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistry*. 6th Ed. W.H. Freeman and Co.
12. Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry*. IV Edition. W.H. Freeman and Co.
13. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry*. XXVIII edition. Lange Medical Books/ McGraw-Hill.
14. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

15. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

**SEMESTER-V**

**Paper Code: CH502C (Th + Pr)**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-10**

**Major**

**Group –A: Physical Chemistry, 02 Credits, Marks: 50**

**UNIT-I: Electrochemistry**

**(15 Lx 45 minutes)**

**Electrical transport:** Conductance, specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar, equivalent and specific conductances with dilution. Migration of ions and Kohlrausch law, activity & activity coefficient coefficient, ionic strength, Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only), Asymmetric effect, Electrophoretic effect, Wien effect, Debye-Falkenhagen effect, Walden's rules,. Transport number, definition and determination by Hittorf method and moving boundary method. Ionic mobility. Application of conductance measurement- determination of solubility, dissociation constant & conductometric Titrations

**Electrochemical cell:** Single electrode potential,. Nernst equation and its thermodynamic derivation; Relation between emf and free energy & Cell thermodynamics, Reference Electrodes ( Hydrogen electrode, Calomel electrode, Quinhydrone electrode, glass electrode), Electrode potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i, equilibrium constants, and (ii) pH values, using hydrogen, calomel, Quinone-hydroquinone, glass electrodes.( iii) determination of activity coefficients (iv) solubility product (v)dissociation constant of weak acid (vi) Potentiometric titrations (acid-base, redox, precipitation).; Concept and types of Concentration cells with and without transference, liquid junction potential;. Elementary ideas of polarizations and overvoltage-related theories, Tafel equation, Corrosion – types, theories, factors and prevention. Different types of commercial cells -Lead and alkali accumulators, fuel cell.

**UNIT-II: Phase Equilibrium**

**(15 Lx 45 minutes)**

Clausius-Clapeyron equation and its applications to solid-liquid, Distribution Law, Solvent Extraction, Equilibrium constant from Distribution Law, Nernst distribution law Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system– water, CO<sub>2</sub> and sulphur systems.

Binary alloy: solid solutions (Au-Ag system), ( Pb-Ag system), ( Cu-Ni system), ( Mn-Cu system), (Cu-Ag system), ( Pb-Sn system).

Binary solutions: Liquid-Liquid phase system (Phenol- water, Water- Trimethyl amine, Water- nicotine system etc. ) Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Three component systems, water-chloroform-acetic acid system, Pb-Bi-Sn System, Triangular plots & its application.



### **Group –B: Practical, 02 Credits, Marks: 50**

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Distribution of distribution co-efficient of ammonia between water and chloroform.
3. Determination of partition coefficient of benzoic acid between water and nonpolar organic solvent.
4. Determination of cell constant.
5. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
6. Perform the following conductometric titrations: Strong acid vs. strong base and determine the strength of acid solution.
7. Perform the following conductometric titrations: weak acid vs. strong base and determine the strength of weak acid solution.
8. Perform the following conductometric titrations: acetic acid & hydrochloric acid mixture vs. strong base and determine the strength of unknown acid solution.
9. Perform the following conductometric titrations:  $\text{Na}_2\text{SO}_4/\text{K}_2\text{SO}_4$  solution vs. strong base and determine the strength of salt solution.
10. Perform the following potentiometric titrations: Strong acid vs. strong base & find out the strength of acid solution
11. Perform the following potentiometric titrations: weak acid vs. strong base & find out the strength of acid solution
12. Perform the following potentiometric titrations: Potassium dichromate vs. Mohr's salt & find out the concentration of  $\text{Fe}^{+2}$

### **Recommended Books:**

1. S. Glasstone, *An Introduction to Electrochemistry*.
2. V. S Bagotsky, *Handbook of Electrochemistry... Fundamentals of electrochemistry I—2nd ed.*
3. P.C. Rakhit, *A Textbook of Physical Chemistry. Volume 3.*
4. K.L. Kapoor, *Physical Chemistry, 7th edition..*
5. A. S. Negi, S. C. Anand, *A Textbook of Physical Chemistry*
6. B. D. Khosla, V. C. Garg, & A. Gulati, *Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).*
7. C. W. Garland, J. W. Nibler, & D. P. Shoemaker, *Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill: New York (2003).*
8. A. M. Halpern, & G. C. McBane, *Experimental Physical Chemistry, 3rd Ed.; W.H. Freeman & Co.: New York (2003).*

**SEMESTER-V**  
**Paper Code: CH503C (Th)**  
**Credit: 04, Total Marks: 100**  
**Name of Paper: Chemistry-11**

**Major**

**Group –A: Inorganic Chemistry, 02 Credits, Marks: 50**

**UNIT-I: Transition Metals (d-block)**

**(15 L× 45 minutes)**

Electronic configuration of d-block elements, general properties, oxidation states, complex formation, spectral & magnetic properties;

Preparation, important reactions, structure and uses of the nickel tetracarbonyl, Sodium nitroprusside, sodium cobaltinitrite, hexaammine cobalt(III) chloride, potassium ferrocyanide, potassium ferricyanide, Prussian and turnbull's blue, potassium dichromate, potassium permanganate, manganese dioxide, cupric acetate, chromyl chloride.

**UNIT-II: Inner Transition Elements (f-block)**

**(15 L× 45 minutes)**

Electronic configurations, oxidation states, complex formation, spectral & magnetic properties of lanthanides and actinides; lanthanide and actinide contraction and its consequences, separation of lanthanides by ion exchange method. Preparation, important reactions, structures and uses of cerium(IV) sulphate, uranyl nitrate hexahydrate, zinc uranyl acetate and uranium hexafluoride.

**Group –B: Physical Chemistry, 02 Credits, Marks: 50**

**UNIT-I: Fundamentals of Quantum Chemistry**

**(15 L× 45 minutes)**

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids. Atomic spectra, wave particle duality, de-Broglie hypothesis. Heisenberg uncertainty principle. Theory of wave motion, Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function, properties of wave function, condition of normalization and orthogonality, Operators, eigen value & eigen function, different quantum mechanical operators and properties of operators, commutators, postulates of quantum mechanics, particle in a box. Harmonic oscillators, The electronic Schrödinger wave equation for H-atom, equation in spherical coordinates, solving the equation, splitting of the equations in to radial & angular part & their significance.

**UNIT-II: Physical properties & Molecular structure**

**(15 L× 45 minutes)**

Additive and constitutive properties, molar refraction (Lorenz-Laurentz equation) Optical activity, Specific and molar rotation, Optical rotator dispersion, (ORD) and circular dichroism(CD) Basic ideas of electrostatics, Electrostatics of dielectric media, dielectric constant, induced and orientation polarization, Clausius-Mosotti equation, Debye equation,, Dipole moment and molecular polarizabilities and their measurements ( Temperature and refractivity method). Magnetic rotation, Magnetic properties-diamagnetism, paramagnetism and ferromagnetism, origin of magnetism, magnetic moment, magnetic susceptibility and its measurement, Ascertaining the structure of different molecules and ions using above properties.

### **Recommended Books:**

1. J.D. Lee, *Concise Inorganic Chemistry*, 5<sup>th</sup> Edition (ELBS)
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4<sup>th</sup> Edition (Pearson Education)
3. S. K. Basu, R. D. Madan, Satya Prakash and G. D. Tuli, *Advanced Inorganic Chemistry – Vol. 1-2* (S Chand & Co Ltd)
4. R. Sarkar, *General & Inorganic Chemistry, Part-II (Vol. I & II)* (New Central Agency)
5. R. L. Dutta, *Inorganic Chemistry Vol-1 & 2* (New Book Stall)
6. B. R. Puri, L.R. Sharma, Kalia, Kaushal, S & P-block elements, *Transition Metals & Co-Ordination Chemistry*(Vishal Publishing Co.)
7. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry* (Vishal Publishing Co.)
8. Malik, Tuli, Madan, *Selected Topics in Inorganic Chemistry*, Revised Edition, (S Chand & Co Ltd)
9. Shriver and Atkins, *Inorganic Chemistry*, 5<sup>th</sup> Edition, (Oxford University Press)
10. H. J. Arnikar and N. S. Rajurkar, *Nuclear Chemistry* (New Age Int. Publishers)
11. Kapoor, K. L., *A Textbook of Physical Chemistry - Quantum Chemistry and Molecular Spectroscopy I Volume 4*, 6th Edition..
12. Prasad, R.K., *Quantum Chemistry*;, New Age International, 2001
13. Donald A. McQuarrie. *Quantum Chemistry Paperback – 1 December 2016*
14. Chandra, A. K., *Introductory Quantum Chemistry*; Author,; Publisher, Tata McGraw-Hill Education, 1994.
15. Banwell, C. N., *Fundamentals of Molecular Spectroscopy. THIRD EDITION.. Lecturer in Chemistry. University of Sussex. MCGRAW-HILL BOOK COMPANY.*
16. Colin N. Banwell & Elaine M. McCash, *Fundamentals of Molecular Spectroscopy*..
17. Sindhu, P. S., *Fundamentals of Molecular Spectroscopy*, New Age International.

### **SEMESTER-V**

**Paper Code: CH504C (Th + Pr)**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-12**

**Major**

### **Group –A: Organic Chemistry, 02 Credits, Marks: 50**

#### **UNIT-I: Reaction Mechanism**

**(15 L× 45 minutes)**

**Molecular rearrangements:** Dienone-phenol, Wagner-Meerwein, Beckmann, Wolf, Lossen, Hoffman, Curtius, Schmidt, Fries, Demjanov and Favorskii rearrangement.

**Introduction to organic synthesis:** Formation of C – C bonds, base catalysed and acid catalysed reactions with special reference to Dieckmann, Michael, Darzens and Mannich reactions.

**Active methylene Compounds:** Active methylene group, synthesis and applications of ethyl acetoacetate and diethyl malonate in organic synthesis, tautomerism.

#### **UNIT-II: Selective reagents in Organic transformations**

**(15 L× 45 minutes)**

Lithium aluminum hydride, Sodium borohydride, Diisobutylaluminium hydride (DIBAL), Lithiumdiisopropylamide (LDA), PCC, DCC, DDQ, Baker's yeast, Selenium oxide, NBS, NCS, periodic acid and periodate, 9-BBN, mCPBA, peracids, I<sub>2</sub>/AgOAc (aq. and anhydrous condition), KMnO<sub>4</sub> and OsO<sub>4</sub>. Preparation and synthetic applications of Grignard reagents, Organolithium, Organocopper, organozinc compounds.

### **Group –B: Practical, 02 Credits, Marks: 50**

**A. Organic Qualitative analysis:** Identification of the following organic compounds through systematic analysis (determination of mp, solubility test, detection of special elements, detection of functional groups, preparation of suitable derivative, determination of  $R_f$  value on TLC and survey of literature)

**List of compounds to be identified:** Cinnamic acid, succinic acid, salicylic acid, p-hydroxy benzoic acid,  $\beta$ -naphthol, resorcinol, o-chlorobenzoic acid, phthalic acid, benzamide, phthalimide, benzanilide, acetanilide, benzil, benzophenone, glucose, vaniline, anthracene, diphenyl, urea.

#### **Recommended Books:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Edu)*.
2. Finar, I. L. *Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)*.
3. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)*.
4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976)*.
5. Graham Solomons, T.W. *Organic Chemistry, John Wiley & Sons, Inc.*
6. McMurry, J.E. *Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013*.
7. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.*
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry, Oxford University Press*
9. S. C. Das, *Advanced Practical Chemistry, 3<sup>rd</sup> Edition (Kolkata S.C, Das)*
10. N.K. Vishnoi, *Advanced Practical Organic Chemistry, Vikas Publishing House*
11. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry, Pearson Education (2009)*.
12. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed. Pearson (2012)*.
13. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000)*.

### **SEMESTER-VI**

**Paper Code: CH601C (Th)**

**Major**

**Credit: 04, Total Marks: 100**

**Name of Paper: Chemistry-13**

### **Group –A: Organic Chemistry, 02 Credits, Marks: 50**

#### **UNIT-I: Spectroscopy**

**(15 L× 45 minutes)**

**UV Spectroscopy:** Types of electronic transitions,  $\lambda_{max}$ , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of  $\lambda_{max}$  for the following systems:  $\alpha, \beta$  unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

**IR Spectroscopy:** Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

**Proton NMR spectroscopy:** Introduction, theory, sample handling, chemical shift and factors influencing it, spin-spin coupling, characteristic chemical values of different kind of protons, application of UV, IR and NMR in structure elucidation of organic molecules.

**UNIT-II: Natural Products****(15 L× 45 minutes)**

**Terpenoids:** Introduction, Natural occurrence, General structural features, classification, isoprene rule, isolation, structure elucidation and synthesis of citral, terpineol, geraniol and limonene.

**Alkaloids:** Introduction, classification, isolation, structure elucidation and synthesis of nicotine, piperine, Morphine, Reserpine, Hygrine, Cocaine and Coniine.

**Anthocyanins:** Introduction, general characteristics, methods of isolations, structure elucidations and synthesis. Structure elucidation of cyanin, pelargonin, delphinin, peonin, malvin, and hirsutin.

**Group –B: Physical Chemistry, 02 Credits, Marks: 50****UNIT-I: Spectroscopy****(15 L× 45 minutes)**

Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

**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.

**UNIT-II: Photochemistry****(15 L× 45 minutes)**

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus- Drapper law, Stark-Einstein law, absorbance & molar absorptivity, consequence of light absorption by molecules, electronic transitions in molecules, potential energy curves for primary photochemical process, Jablonski diagram depicting various processes occurring in the excited state, Luminescence, qualitative description of fluorescence, types of fluorescence, phosphorescence, Chemiluminescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), quenching. Role of photochemical reactions in biochemical processes, kinetics of photochemical reaction.

**Recommended Books:**

1. Y R Sharma, *Elementary Organic Spectroscopy*, S. Chand Limited
2. William Kemp, *Organic Spectroscopy*, Palgrave
3. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
4. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Banwell, C. N., *Fundamentals of Molecular Spectroscopy. THIRD EDITION. Lecturer in Chemistry.*
6. University of Sussex. *MCGRAW-HILL BOOK COMPANY.*
7. Colin N. Banwell & Elaine M. McCash, *Fundamentals of Molecular Spectroscopy*,.
8. Sindhu, P. S., *Fundamentals of Molecular Spectroscopy*, New Age International.
9. K.K. Rahatgi Mukherjee, *Photochemistry*, New Age International Publisher.

**SEMESTER-VI**  
**Paper Code: CH602C (Th + Pr)**  
**Credit: 04, Total Marks: 100**  
**Name of Paper: Chemistry-14**

**Major**

**Group –A: Inorganic Chemistry, 02 Credits, Marks: 50**

**UNIT-I: Bio-inorganic Chemistry**

**(15 L× 45 minutes)**

(i) Essentials and trace elements of life, ionophores and siderophores, membrane transport (active and passive transport process); sodium / potassium-pump. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, deficiency of Fe, Ca and iodine and consequences; use of chelating agents in medicine (chelation therapy), platinum complexes as anti-cancer drugs.

(ii) Active site structure and functions of haemoglobin, myoglobin and role of iron and globin chain in haemoglobin, active site structure of chlorophyll and role of magnesium and phytyl group in chlorophyll, role of Co in vitamin B<sub>12</sub>. Metalloenzymes-Carbonic anhydrase, Carboxypeptidase, hemocyanin-active site structures and functions.

**UNIT-II: Organometallic Chemistry**

**(15 L× 45 minutes)**

Definition and classification of organometallic compounds, concept of hapticity. 18 & 16 electron rule, electron counts scheme. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.  $\pi$ -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and explanation of  $\pi$ -back bonding

Zeise's salt: Preparation and structure

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), structure and aromaticity.

Study of the following catalytic processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Polymerisation of alkene (Ziegler-Natta Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process (PdCl<sub>2</sub>)
4. Synthetic gasoline (Fischer Tropsch reaction)

**Group –B: Practical, 02 Credits, Marks: 50**

**Qualitative analysis of mixtures of inorganic salts** containing **five** radicals (at least one interfering radical) from the following lists. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>, S<sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>, CrO<sub>4</sub><sup>2-</sup>, F<sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>, BO<sub>3</sub><sup>3-</sup>, PO<sub>4</sub><sup>3-</sup>, NH<sub>4</sub><sup>+</sup>, K<sup>+</sup>, Pb<sup>2+</sup>, Cu<sup>2+</sup>, Cd<sup>2+</sup>, Sn<sup>2+</sup>, Bi<sup>3+</sup>, Sb<sup>3+</sup>, Fe<sup>3+</sup>, Al<sup>3+</sup>, Cr<sup>3+</sup>, Zn<sup>2+</sup>, Mn<sup>2+</sup>, Co<sup>2+</sup>, Ni<sup>2+</sup>, Ba<sup>2+</sup>, Sr<sup>2+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>.

Mixtures should preferably contain one interfering anion **or** insoluble component (BaSO<sub>4</sub>, SrSO<sub>4</sub>, PbSO<sub>4</sub>, CaF<sub>2</sub> or Al<sub>2</sub>O<sub>3</sub>) **or** combination of anions e.g. NO<sub>2</sub><sup>-</sup> and NO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup> and Br<sup>-</sup>, Cl<sup>-</sup> and I<sup>-</sup>, Br<sup>-</sup> and I<sup>-</sup>, NO<sub>3</sub><sup>-</sup> and Br<sup>-</sup>, NO<sub>3</sub><sup>-</sup> and I<sup>-</sup>. **Spot tests and green methods may be followed if possible.**

## Quantitative Inorganic estimation

### Volumetric titrations:

- i. Estimation of  $\text{Fe}^{+2}/\text{Ca}^{+2}$  by EDTA
- ii. Estimation of  $\text{Cu}^{+2}/\text{Fe}^{+2}$  by iodometric method
- iii. Estimation of  $\text{Cu}^{+2}/\text{Zn}^{+2}$  by EDTA
- iv. Estimation of  $\text{CO}_3^{2-} + \text{HCO}_3^-$  in a mixture

### Complexometric Titrations

- i. Estimation of  $\text{Ca}^{2+}$  in milk powder by EDTA.
- ii. Determination of total hardness of water.

### Recommended Books:

1. Asim K Das, *Bioinorganic Chemistry (New Central)*
2. G. N. Mukherjee and A. Das, *Elements of Bio-Inorganic Chemistry (U. N. Dhur & Sons Pvt. Ltd)*
3. ROSETTE M, ROAT-MALONE, *Bioinorganic Chemistry: A short course, 3<sup>rd</sup> Edition (WileyIndia Pvt. Ltd)*
4. Indrajit Kumar, *Organometallic Compounds (Pragati Prakashan)*
5. F. A. Cotton, G. Wilkinson and Paul L Gaus, *Basic Inorganic Chemistry, 3<sup>rd</sup> Edition (Wiley India Pvt. Ltd)*
6. B C Ray and S N Das, *General and Inorganic Chemistry, 1<sup>st</sup> Edition (NCBA)*
7. F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, *Advanced Inorganic Chemistry, An Indian Adaptation, (Wiley India Pvt. Ltd)*
8. Powell, P, *Principles of Organometallic Chemistry, (Chapman and Hall, 1988)*
9. J. D. Lee, *Concise Inorganic Chemistry, 5<sup>th</sup> Edition (ELBS)*
10. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity, 4<sup>th</sup> Edition (Pearson Education)*
11. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry (Vishal Publishing Co.)*
12. M. M. Nandi, *Essentials of Chemistry (New Age International)*
13. Vogel's *Qualitative Inorganic Analysis, Revised by G. Shelva, 7<sup>th</sup> Edition (Prentice Hall)*
14. Ghoshal, Mahapatra, Nad, *An advanced course in practical Chemistry (NCBA)*
15. S. C. Das, *Advanced Practical Chemistry 3rd Edition*

## SEMESTER-VI

Paper Code: CH603C (Th)

Credit: 04, Total Marks: 100

Name of Paper: Chemistry-15

Major

### Group –A: Environment and Green Chemistry, 02 Credits, Marks: 50

#### UNIT-I: Environment Pollution

(15 L × 45 minutes)

**Air Pollution:** Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by  $\text{SO}_2$ ,  $\text{CO}_2$ ,  $\text{CO}$ ,  $\text{NO}_x$ ,  $\text{H}_2\text{S}$  and other foul smelling gases. Methods of estimation of  $\text{CO}$ ,  $\text{NO}_x$ ,  $\text{SO}_x$  and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

**Water Pollution:** Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and

ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

#### **UNIT-II:**

**(15 L× 45 minutes)**

**Drugs and pesticides:** Introduction, classification of drugs, preparation and uses of aspirin, paracetamol, ibuprofen, phenacetin, sulphanilamide, sulphaguanidine, diazepam, ranitidine. Introduction and Classification of pesticides, natural and synthetic pesticides, preparation and uses of DDT, endrin, melathion, parathion and baygon.

**Green Chemistry:** Principles of green chemistry, atom economy, Environmental factor. Green: synthesis, chemicals, catalysts and recyclability, reaction conditions. Green methods for removal of pollutants. Use of green reagents, green catalysts (Zeolites, enzymes etc.) and green solvents; applications of green chemistry (from laboratory to industries).

#### **Group –B: Analytical Methods in Chemistry, 02 Credits, Marks: 50**

#### **UNIT-I: Chromatography**

**(15 L× 45 minutes)**

Basic concept of chromatographic separation – adsorption and partition chromatography, theory and handling of different chromatographic techniques – column, thin-layer, and paper chromatography. Gas chromatography: Basic principle, basic equipment; types of column and their selection; detectors (FID, TCD, ECD, NPD); sample separation and applications. High performance liquid chromatography (HPLC): Instrumentation - basic equipment; pumping and injection system, column and its packing, normal and reverse phases; detectors, sample separation and application. Gel permeable (filtration) chromatography, Size exclusion chromatography, gel electrophoresis, Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose gel electrophoresis, pulse field gel electrophoresis, immuno-electrophoresis, isoelectric focusing, Western blotting.

#### **UNIT- II: Spectroscopy & Microscopy**

**(15 L× 45 minutes)**

**Flame Atomic Absorption Spectroscopy:** Principles of atomic absorption spectroscopy, Radiation sources, Flame and electrothermal atomization, Limitations in atomic absorption, Interferences, Comparison of absorption spectrometry techniques-flame and graphite furnace, Quantitative Analysis, inductively coupled plasma-mass spectroscopy (ICP-MS).

**Flame Atomic Emission Spectroscopy:** Atomic emission, Principles of flame emission photometry, Limitations of flame emission photometry, Interference, Qualitative Analysis, Quantitative Analysis, Comparison of flame atomic emission and absorption spectroscopy. Excitation sources in atomic emission spectroscopy, ICP-AES spectroscopy. Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared, centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles. Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM),

#### **Recommended books:**

1. K. De, *Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.*
2. S. M. Khopkar, *Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.*
3. S.E. Manahan, *Environmental Chemistry, CRC Press (2005).*
4. G.T. Miller, *Environmental Science 11th edition. Brooks/ Cole (2006).*



- A. Mishra, *Environmental Studies. Selective and Scientific Books, New Delhi (2005).*
5. V K Ahluwalia "Green Chemistry: Environmentally Benign Reactions"
6. V K Ahluwalia and M Kidwai, "New Trends in Green Chemistry"
7. Cremllyn, R. *Pesticides. Preparation and Modes of Action, John Wiley & Sons, New York, 1978.*
9. Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.*
11. Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.*
13. Karp, G. 2010. *Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.*
14. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. *Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.*
15. Cooper, G.M. and Hausman, R.E. 2009. *The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.*
16. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 *The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.*
17. Svehla, G. *Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.*
18. Mendham, J. *Vogel's Quantitative Chemical Analysis, Pearson, 2009.*
19. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.*
20. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry Orient-Longman, 1960.*

#### SEMESTER-VI

Paper Code: CH604C (Th + Pr)

Major

Credit: 04, Total Marks: 100

Name of Paper: Chemistry-16

#### Group –A: Industrial Chemistry, 02 Credits, Marks: 50

##### UNIT-I: Industrial chemistry – I

(15 L× 45 minutes)

**Enzymes in industries:** Production of alcohol by fermentation of starch and sugar (reaction conditions, nature of enzymes used, structural transformation during reaction). Preparation and use of cellulose.

**Oils, Fats and Detergents:** Catalytic hydrogenation of vegetable oil and fat for production of soap, synthesis of detergents. Principles of cleansing action.

**Coal and Petroleum:** Cracking of petroleum, knocking and octane number. Synthetic petrol, LPG and CNG, Biodiesel.

##### UNIT-II: Industrial chemistry – 2

(15 L× 45 minutes)

**Fertilisers:** Different types of N and P fertilizers, manufacture of ammonia, ammonium nitrate, urea phosphates and superphosphates. Nitrogen fixation by plants.

**Glass:** Various types of glass fibers, optical glass, glazing and vitrification, glass ceramics.

**Cement:** Various types of cement, their composition and manufacture. Portland cement, setting of cement.

**Paints:** Constituents of different paints, Role of binder and solvent, Lead and Zinc containing paints, common use of paints.

### **Group –B: Practical, 02 Credits, Marks: 50**

#### **Organic Preparation**

Acid and Base catalyzed aldol condensation (Synthesis of dibenzalpropanone), 7-hydroxy-4-methylcoumarin from resorcinol and ethylacetoacetate (Pechmann condensation).

#### **Quantitative Analysis**

- i. Estimation of total hardness of a supplied water sample.
- ii. Estimation of the amount of iron present in a supplied cement sample.
- iii. Determination of saponification value of a supplied vegetable oil/ester.
- iv. Determination of iodine value of a supplied vegetable oil/unsaturated ester.
- v. Determination of chemical oxygen demand(COD) of a supplied water sample
- vi. Determination of available chlorine in supplied bleaching powder.
- vii. Extraction of caffeine from tea leaves
- viii. Preparation of Biodiesel from vegetable oil.

#### **Recommended Books:**

1. *Asim K Das, Bioinorganic Chemistry (New Central)*
2. *G. N. Mukherjee and A. Das, Elements of Bio-Inorganic Chemistry (U. N. Dhur & Sons Pvt. Ltd)*
3. *ROSETTE M, ROAT-MALONE, Bioinorganic Chemistry: A short course, 3<sup>rd</sup> Edition (WileyIndia Pvt. Ltd)*
4. *Indrajit Kumar, Organometallic Compounds (Pragati Prakashan)*
5. *F.A. Cotton, G. Wilkinson and Paul L Gaus, Basic Inorganic Chemistry, 3<sup>rd</sup> Edition (Wiley India Pvt. Ltd)*
6. *B C Ray and S N Das, General and Inorganic Chemistry, 1<sup>st</sup> Edition (NCBA)*
7. *F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Advanced Inorganic Chemistry, An Indian Adaptation, (Wiley India Pvt. Ltd)*
8. *Powell, P, Principles of Organometallic Chemistry, (Chapman and Hall, 1988)*
9. *J.D. Lee, Concise Inorganic Chemistry, 5<sup>th</sup> Edition (ELBS)*
10. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4<sup>th</sup> Edition (Pearson Education)*
11. *S C Das, Advanced Practical Chemistry, 3<sup>rd</sup> Edition (Kolkata S.C, Das)*
12. *C. Ranu, Monograph on Green Chemistry Laboratory Experiments (Green Chemistry Task Force Committee, DST).*
13. *Vogel's Qualitative Inorganic Analysis, Revised by G. Shelva,, 7<sup>th</sup> Edition (Prentice Hall)*
14. *Ghoshal, Mahapatra, Nad, An advanced course in practical Chemistry (NCBA)*
15. *G N Mukherjee, Advanced Experiments in Inorganic Chemistry (U. N. Dhur & Sons Pvt. Ltd)*
16. *C. K. Sharma, Industrial Chemistry (Part1 &2) (Krishna Prakashan)*
17. *Prakash G. More, Comprehensive Industrial Chemistry*
18. *Vogel's Qualitative Inorganic Analysis, Revised by G. Shelva, 7<sup>th</sup> Edition (Prentice Hall)*
19. *Ghoshal, Mahapatra, Nad, An advanced course in practical Chemistry (NCBA)*
20. *S. C. Das, Advanced Practical Chemistry 3rd Edition*

**Semester-I**  
**Minor course 1 (MC-1): CH 101 M**  
**Fundamentals of Chemistry**  
**Credits: 03, Full Marks: 75**

**Unit I: Atomic Structure and Periodicity of Elements** (Credit-1, 15 Lx 45 minutes)

Bohr's atomic structure and its limitations, atomic spectrum of hydrogen atom; de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau principle and its limitations.

Periodic classification of elements on the basis of electronic configuration; Periodic properties – atomic radii, ionic radii, covalent radii; ionization potential, electron affinity, electronegativity, ionization enthalpy, factors affecting ionization enthalpy. applications of ionization enthalpy. Pauling's scale of electronegativity, group electronegativity; Mulliken, Allred Rochow scales, electronegativity and bond order, partial charge, group electronegativity.

**Unit II: Basics of Organic Chemistry** (Credit-1, 15 Lx 45 minutes)

Concept of hybridization, hybrid orbitals and molecular geometry, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, Van der Waals interactions, hyperconjugation, Dipole moment; Electronic Displacements: Inductive effect, resonance, mesomeric effects and their applications; acidity and basicity of organic compounds; Mechanism of Organic Reactions: homolytic and heterolytic bond fission, Types of reagents – electrophiles and nucleophiles, Types of organic reactions, examples of reactive intermediates – Carbocations, carbanions, free radicals, carbenes, arynes and nitrenes.

**Unit III: Properties and Kinetic theories of gases** (Credit-1, 15 Lx 45 minutes)

Gas laws, behaviour of real gases, PV isotherms of real gases, deviation from ideal behavior of gases, van der Waals equation of state; Critical phenomena: continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state, postulates of kinetic theory of gases, gas pressure, kinetic theory of gases ( $PV = \frac{1}{3} mnc^2$ ), average kinetic energy of molecules, mean free path, collision diameter, collision number, collision frequency, their dependence on temperature and pressure, heat capacity of gases, atomicity of molecule, viscosity of gases; Maxwell's distribution of molecular velocities.

**Minor course 1 (MC – 1): CH 101M (Practical)**  
**Credits: 01, Full Marks: 25**

**Titrimetric Analysis**

- (A) Preparation of solutions of different Molarity/Normality.
- (B) Acid-Base Titrations
  - (i) Estimation of oxalic acid in a given solution by standard NaOH
  - (ii) Estimation of percentage of acetic acid in a commercial vinegar sample
  - (iii) Estimation of carbonate and bicarbonate present together in a mixture.
- (C) Oxidation-Reduction Titration
  - (i) Estimation of Fe (II) using standardized  $\text{KMnO}_4$  solution.
  - (ii) Estimation of Fe(II) using standard  $\text{K}_2\text{Cr}_2\text{O}_7$

**Recommended books:**

1. Lee, J.D. *Concise Inorganic Chemistry*, Pearson Education 2010.
2. Huheey, J.E., Keiter, E.A., Keiter, R.L., Medhi, O.K. *Inorganic Chemistry, Principles of Structure and Reactivity*, Pearson Education 2006.
3. Douglas, B.E. and Mc Daniel, D.H., *Concepts & Models of Inorganic Chemistry*, Oxford
4. Atkins, P.W. & Paula, J. de *Atkin's Physical Chemistry Ed.*, Oxford University Press 2006.
5. Ball, D.W. *Physical Chemistry Thomson Press* 2007.
6. Castellan, G.W. *Physical Chemistry 4th Ed.* Narosa 2004.
7. Singh J., Yadav L.D.S., *Advanced Organic Chemistry, Pragati Edition*
8. Morrison, R.N. & Boyd, R.N. *Organic Chemistry*, Pearson Education.
9. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003
10. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
11. Harris, D. C. *Quantitative Chemical Analysis. 6th Ed.*, Freeman (2007) Chapters 3-5.

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**Semester-II**  
**Minor course 2 (MC-2): CH 201 M**  
**Selected Topics in Chemistry -I**  
**Credits: 03, Full marks: 75**

**Unit I: Bonding and intermolecular Forces**

**(Credit-1, 15 Lx 45 minutes)**

Bonding ( $\sigma$  and  $\pi$  bond approach) and bond lengths, the Valence bond theory (VBT), Bent's rule, Valence shell electron pair repulsion theory (VSEPR), shapes of the simple molecules and ions containing lone pairs and bond pairs of electrons; Molecular orbital theory (MOT): Molecular orbital diagrams, bond orders homonuclear and heteronuclear diatomic molecules and their ions ( $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{C}_2$ ,  $\text{B}_2$ ,  $\text{F}_2$ ,  $\text{CO}$ ,  $\text{NO}$ ); Resonance and resonance energy, formal charge, Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction, dipole moment of diatomic and polyatomic molecules, Percentage ionic character from dipole moment, polarizing power and polarizability. Fajan's rules, H- bonding and its consequences. Ionic and metallic bonds.

**Unit II: Chemical Kinetics****(Credit-1, 15 Lx 45 minutes)**

Rate of a reaction, concentration dependence of rates, and mathematical characteristic of simple chemical reactions, Order and molecularity of a reaction, – zero order, first order, second order, pseudo 1<sup>st</sup> order, half-life and mean life. Determination of the order of a reactions – differential method, method of integration, half-life method and isolation method.

**Theories of chemical kinetics:** Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory. Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).

**Unit III: Basic Stereochemistry of organic molecules****(Credit-1, 15 Lx 45 minutes)**

Concept of isomerism, types of isomerism; optical isomerism – elements of symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereo centers, diastereomers, threo and erythro, meso compounds, resolution of enantiomer, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Newman projection and Sawhorse formulae, Fischer and flying wedge formulae, Difference between configuration and conformation. Geometrical isomerism – determination of configuration of geometric isomers, E & Z system of nomenclature. Conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives.

**Minor course 2 (MC – 2): CH 201M (Practical)****Credits: 01, Full Marks: 25**

1. Detection of special elements (N, S, Cl) in organic compounds.
2. Purification of organic compounds by crystallization (from water and alcohol) and distillation and determination of melting point to check the purity of the crystallized compound.
3. Preparations: (a) Benzoylation of amines/phenols  
(b) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone  
(c) Acetylation of aniline  
(d) Preparation of phthalimide

**Recommended books:**

1. Douglas, B.E. and Mc Daniel, D.H., *Concepts & Models of Inorganic Chemistry*, Oxford
2. Huheey, J.E., Keiter, E.A., Keiter, R.L., Medhi, O.K. *Inorganic Chemistry, Principles of Structure and Reactivity*, Pearson Education 2006.
3. Lee, J.D. *Concise Inorganic Chemistry*, Pearson Education 2010.
4. Atkins, P.W. & Paula, J. de *Atkin's Physical Chemistry Ed.*, Oxford University Press 2006.
5. Ball, D.W. *Physical Chemistry* Thomson Press 2007.
6. Castellan, G.W. *Physical Chemistry 4th Ed.* Narosa 2004.
7. Singh J., Yadav L.D.S., *Advanced Organic Chemistry*, Pragati Edition
8. Morrison, R.N. & Boyd, R.N. *Organic Chemistry*, Pearson Education.

9. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003
10. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
11. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
12. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
13. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960

**Semester-III**  
**Minor course 3 (MC-3): CH 301 M (Th)**  
**Selected Topics in Chemistry -II**  
**Credits: 03, Full marks: 75**

**Unit I: Coordination Chemistry** **(Credit-1, 15 Lx 45 minutes)**

Werner's theory of coordination complexes, classification of ligands, ambidentate ligands, chelating ligands, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, geometrical and optical isomerism in square planar and octahedral complexes; Metal- ligand bonding in transition metal complexes, limitations of valence bond theory, an elementary idea of crystal field theory. Stability and properties of metal complexes, factors affecting the stability, stability constants of complexes and their determination.

**Unit II: Equilibrium** **(Credit-1, 15 Lx 45 minutes)**

**Chemical Equilibrium:** Equilibrium constant and free energy, thermodynamic derivation of law of mass action. Le-Chatelier's principle, reaction isotherm and reaction isochore– Clapeyron-Clausius equation and its applications.

**Phase Equilibrium :** Statement and meaning of the terms-phase, component and degrees of freedom, derivation of phase rule, phase equilibria of one component system – water, CO<sub>2</sub> and systems. Phase equilibria of two component systems – Solid – liquid.

**Ionic Equilibrium:** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis, calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions, solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

**Unit III: Basics of organic reaction** **(Credit-1, 15 Lx 45 minutes)**

Formation of alkanes, Wurtz reaction, Wurtz-Fittig reaction, Free radical substitutions Mechanism of Halogenation- relative reactivity and selectivity, formation of alkenes and alkynes by elimination reaction. Mechanism of E<sub>1</sub>, E<sub>2</sub>, E<sub>1cb</sub> reaction. Saytzeff and Hofmann eliminations. Addition of HBr to propene, Free radical addition of HBr to propene, carbocation and halonium ions. Stereochemistry of halogen addition to alkenes, ozonolysis of propene. Diel's –Alder reaction and mechanism of allylic and benzylic substitutions, bromination mechanism in propene, 1-butene and toluene. Mechanism of S<sub>N</sub>1 and S<sub>N</sub>2 reactions with suitable examples; Energy profile diagrams, stereochemistry and factors effecting S<sub>N</sub>1 and S<sub>N</sub>2 reactions. elimination reactions, mechanisms of E<sub>1</sub> and E<sub>2</sub> reactions, elimination vs substitution reactions,

Aromatic Electrophilic substitution reactions ( $\sigma$  and  $\pi$  complexes), halogenation, nitration, sulphonation, Friedel Crafts alkylation and acylation with their mechanism; Activating and deactivating groups; ortho, para direction; aromatic nucleophilic substitution reaction:  $S_NAr$  and Benzyne mechanism with suitable examples.

**Minor course 3 (MC – 3): CH 301M (Practical)**  
**Credit: 01, Full Marks: 25**

1. Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .
2. Measurement of pH of different acidic and basic solutions using pH-meter.
3. Measurement of pH of solutions like aerated drinks, fruit juices, shampoos and soaps
4. Preparation and measurement of the pH of the following buffer solutions and comparison of the values with theoretical values.
  - (i) Sodium acetate-acetic acid
  - (ii) Ammonium chloride-ammonium hydroxide

**Recommended books:**

1. *Alberty, R A, Physical Chemistry, 4th edition Wiley Eastern Ltd, 2001.*
2. *Atkins, P.W., the elements of physical chemistry, Oxford, 1991*
3. *Barrow, G. M., International student Edition. McGraw Hill, McGraw-Hill, 1973.*
4. *Cotton, F.A., Wilkinson, G and Gaus, P. L., Basic Inorganic Chemistry, 3rd Edition, Wiley 1995.*
5. *Lee, J.D, Concise Inorganic Chemistry 4th Edition ELBS, 1977*
6. *Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).*
7. *Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.*
8. *Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.*
9. *Carey, F. A., Giuliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.*
10. *Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, 2nd edition, Oxford University Press, 2012.*

**Semester-IV**  
**Minor course 4 (MC-4): CH 401 M (Th)**  
**Polymer Chemistry**  
**Credits: 03, Full Marks: 75**

**Unit-I: Basics of polymeric materials** **(Credit-1, 15 Lx 45 minutes)**

Classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, texture of polymers, polymerization processes, degrees of polymerization. Bifunctional systems, Poly-functional systems; Polymerization reactions – addition and condensation, step growth, radical, chain growth, and coordination polymerizations. Copolymerization, polymerization techniques, molecular weight of polymers and their determination ( $M_n$ ,  $M_w$ ,  $M_v$ ,  $M_z$ ) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature ( $T_g$ ) and outlines of factors affecting glass transition temperature ( $T_g$ ).

## Unit II: Natural Polymers

(Credit-1, 15 Lx 45 minutes)

Introduction, classification, structure and applications of bio-polymers viz. cellulose, cotton, wool, silk, paper, natural rubber, collagen, hyaluroran- melanin, lignin. Monomers and polymers from renewable resource materials viz. castor oil, natural gums, oleo chemicals, cashew nut shell liquid, carbohydrates, furfural. Structure of Proteins, nucleic acids and polysaccharides.

## UNIT-III: Synthetic polymers

(Credit-1, 15 Lx 45 minutes)

Preparation, structure, properties and applications of the polymers: polyolefins, polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6,6). Thermosetting polymers - phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, conducting polymers (polyacetylene, polyaniline). Brief outline of biodegradable polymers. Manufacture, general properties and applications of styrene-butadiene rubber (SBR), Polyisoprene, Polybutadiene, Butyl rubber, Ethylene –propylene rubber, Neoprene rubber, Speciality rubbers: Silicon rubbers, Nitrile rubbers, Polyacrylic rubbers –Polyurethane rubbers –Hypalon –Fluorocarbon elastomers – Thermoplastic elastomer, reclaimed rubber, foam rubber; Synthetic rubber - SBR - manufacturing process - comparison of properties of SBR with NR - compounding of SBR.

### Minor course 4 (MC-4): CH 401 M (Practical)

Credit: 01, Full Marks: 25

1. Determination of surface tension by (i) drop number (ii) drop weight method.
2. Studies on the variation of surface tension of detergent solutions with concentration.
3. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
4. Studies on the variation of viscosity of sucrose solution with the concentration of solute.
5. Determination of molecular weight of polymer by viscometry.
6. Determination of acid value/saponification value of fats/oils/resin.

### Recommended books:

1. Mark, J.E. Alcock H.R. and Lampe, F.W. *Contemporary Polymer Chemistry*- Prentice Hall Publishers, 3rd Edition; 2005.
2. Charles E. Carroher Jr., *Introduction to Polymer Chemistry*-by CRC Press, Taylor & Francis, Boca Raton, 2010.
3. Lehninger, L., Nelson, D L., Cox, M.M *Principles of Bio-Chemistry*, 1970
4. Awapara, *Introduction to Biological Chemistry*, Prentice Hall, 1968.
5. Saunders, K.J. *Organic Polymer Chemistry* –2nd Edition, Chapman & Hall. 1973
6. Methven, J.M. *Polymeric Materials from Renewable Resources* – RAPR Technology Ltd., Pergamon Press, 4 (7) 1991.
7. Carrahar E.D. and Sperling, L.H. *Polymer Applications of Renewable Resource Materials* – by Plenum Press, New York (1981).
8. Bahadur, P. Sastry, N.V - *Principles of Polymer Science*- Narosa Publishing House. 2002



9. Nayak P.L., *Polymer Chemistry*, Kalyani Publisher (2017).
10. Gowarikar, V. R. Sreedhar, J.; Viswanathan, N. V. *Polymer Science 1st Edition*, New Age International Publishers, 1986.
11. Ghosh, P. *Polymer Science and Technology: Plastics, Rubber, Blends and Composites*, 3<sup>rd</sup> Edition, McGraw Hill Education, 2010.
12. Hundiwale G.D., Athawale V.D., Kapadi U.R. and Gite V. V., *Experiments in Polymer Science*, New Age Publications (2009).
13. Malcolm P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed.

**Semester-V**  
**Minor course 5 (MC-5): CH 501 M (Th)**  
**Bimolecular chemistry**  
**Credits: 03, Full Marks: 75**

**Unit I: Carbohydrates** **(Credit-1, 15 Lx 45 minutes)**

Classification of carbohydrates; reducing and non-reducing sugars; general properties of glucose and fructose, their open chain structure; epimers, mutarotation and anomers; mechanism of mutarotation, osazone formation; determination of configuration of glucose (Fischer's proof). Cyclic structure (Haworth projections) of glucose, fructose; inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses); linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose); metabolism of glucose.

**Unit II: Amino acids, peptides and proteins** **(Credit-1, 15 Lx 45 minutes)**

Classification of  $\alpha$ -amino acids, zwitter ion structure and isoelectric point; single and three letters code of amino acids; essential, glucogenic and ketogenic amino acids; introduction on peptides, N-terminal and C-terminal peptide residue, Determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (with carboxypeptidase enzyme) residues; total hydrolysis and partial hydrolysis of peptides; overview of primary, secondary, tertiary and quaternary structure of proteins; Protein denaturation/ renaturation; coagulation of proteins.

**Unit III: Fats, oils and Lipids** **(Credit-1, 15 Lx 45 minutes)**

Introduction to oils, fats and fatty acids; classification of lipids, common fatty acids present in oils and fats, biological importance of fatty acids and lipids, essential fatty acids:  $\omega$ -3 and  $\omega$ -6 fatty acids; mono and polyunsaturated fatty acids and their significance, trans fatty acids, Hydrogenation of fats and oils, Saponification value, acid value, iodine value; reversion and rancidity; metabolism fatty acids, oxidation of fatty acids (alpha, beta, and omega), ketone bodies and their significance; Structure, sources and functions of prostaglandins, biosynthesis of prostaglandins, inhibition of prostaglandin synthesis.

**Minor course 5 (MC-5): CH 501 M (Practical)**  
**Credit: 01, Full Marks: 25**

1. Differentiate between a reducing/ non reducing sugar
2. Synthesis of Osazones from glucose and fructose
3. Detection of protein by the Biuret reaction.
4. Estimation of quantity of glycine by Sorensen's formylation method.
5. Determination of iodine value of an oil/fat

**Recommended books**

1. *Clayden, J.;Greeves, N.; Warren, S.;Wothers, P.Organic Chemistry, (2001) Oxford Univ. Press, Oxford.*
2. *Barrett G. C.and Elmore, D. T. Amino acids and peptides (2004), Cambridge University press.*
3. *Gustone, F. D. Fatty acid and Lipid Chemistry (1996), Wiley*
4. *Bhtani, S. P. Chemistry of Biomolecules (2010), CRC Press*
5. *R. J. Simmonds,Chemistry of Biomolecules : An Introduction, , RSC, 1992.*
6. *Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. 7<sup>th</sup> Edition. W H Freeman & Co (Sd). 2017.*
7. *Power C.B. and Chatwal. G.R. Biochemistry, Himalayan Publishing House. 4<sup>th</sup> edition 1999.*
8. *Vance, J.E Vance, D.E Biochemistry of Lipids, Lipoproteins and Membranes. Amsterdam: Elsevier (2002).*

**Semester-VI**  
**Minor course 6 (MC-6): CH 601 M (Th)**  
**Chemistry of life process**  
**Credits: 03, Full Marks: 75**

**Unit I: Bioinorganic Chemistry** **(Credit-1, 15 Lx 45 minutes)**

Essential metal ions present in biological systems and their role, classification of elements according to their action in biological system, basic bioenergetics, Structure and function of biological membranes, active transport of cations across membrane, Crown ether complexes of Na and K, ionophores, Sodium /Potassium pump; carbonic anhydrase and carboxypeptidase. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine; Pt-complexes as anticancer drugs, Iron and Haemoglobin.

**Unit II: Enzyme Chemistry** **(Credit-1, 15 Lx 45 minutes)**

**Enzymes and Mechanism of Enzyme Action:** General aspects of enzymes; nomenclature, classification and specificity, isolation, purification and function of enzymes. enzyme specificity, active sites. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, Kinetics of enzyme action – Michaeli's-Menten equation, Different plots for determination of  $K_m$  and  $V_{max}$  and their physiological significance; Enzyme regulation & drug design, Fischer's lock and key and Koshland's induced fit hypothesis.

Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition). Enzymatic hydrolysis of peptides (carboxy peptidase, trypsin, chymotrypsin and Lys C).

### **Unit III: Medicinal Chemistry**

**(Credit-1, 15 Lx 45 minutes)**

Concepts of drugs, classification, Drug discovery, drug design and drug development; analogues and pro-drugs, soft drugs, Structure Activity Relationships (SAR) of drug molecules, Quantitative Structure Activity Relationship (QSAR); ADME; Synthesis and applications of aspirin, paracetamol, Chloramphenicol, Sulphonamides, Sulphanethoxazol, Sulphacetamide, acyclovir, Phenobarbital, Diazepam, Glyceryl trinitrate; an elementary concept on antibiotics; broad spectrum and narrow spectrum antibiotics. Medicinal values of curcumin (haldi), azadirachtin (neem), piperine (black pepper), vitamin C and essential oils.

### **Minor course 6 (MC-6): CH 601 M (Practical)**

**Credit: 01, Full Marks: 25**

1. Preparation of Ni-DMG complex
2. Preparation of potash alum
3. Estimation of proteins by Lowry's method.
4. Preparation of Aspirin and its analysis.

### **Recommended books:**

1. Das, A. K., *Bioinorganic Chemistry, Books & Allied Ltd, 2013*
2. Bertini, Ivano G, Harry B, Lippard, S. J, Valentine, J.S. *Bioinorganic Chemistry, University Science Books, CA, 1994.*
3. Cowan, J.A. *Inorganic Biochemistry: An Introduction, 2<sup>nd</sup> Edition, Wiley-VCH, 1997*
4. Hanzlik, R. P. *Inorganic Aspects of Biological and Organic Chemistry,, Academic Press, New York, 1976*
5. *Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. 7<sup>th</sup> Edition. W H Freeman & Co (Sd). 2017.*
6. *Bioorganic and Bioinorganic and Supramolecular Chemistry. P.S. Kalsi, New Age International (Pvt. Ltd.) 2<sup>nd</sup> edition 2010.*
7. A. Kar, *Medicinal Chemistry, New Age publication*

**Semester-I**

**Interdisciplinary Course 1 (ID-1):**

**Fundamentals of Chemistry**

**Credits: 03**

**Full Marks: 100 (IA = 40 +ESE = 60)**

**Unit I: Atomic Structure and Periodicity of Elements (Credit-1, 15 L× 45 minutes)**

Bohr's theory of atomic structure and its limitations, spectrum of hydrogen atom; de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau principle and its limitations.

Periodic classification of elements on the basis of electronic configuration; Periodic properties – atomic radii, ionic radii, covalent radii; electron affinity, electronegativity, ionization enthalpy, factors affecting electron affinity and ionization enthalpy, applications of ionization enthalpy.

**Unit II: Basics of Organic Chemistry (Credit-1, 15 L× 45 minutes)**

Concept of hybridization, hybrid orbitals and molecular geometry, bond lengths, bond angles, bond energy, localized and delocalized chemical bonding, van der Waals interactions, Dipole moment; Electronic displacements: Inductive effect, resonance, mesomeric effects, hyper conjugation and their applications; acidity and basicity of organic compounds; Mechanism of Organic Reactions: homolytic and heterolytic bond fission, Types of reagents – electrophiles and nucleophiles, Types of organic reactions, examples of reactive intermediates – carbocations, carbanions, free radicals.

**Unit II: Equilibrium (Credit-1, 15 L× 45 minutes)**

**Chemical Equilibrium:** Equilibrium constant and free energy, thermodynamic derivation of law of mass action. Le-Chatelier's principle, reaction isotherm and reaction isochore– Clapeyron-Clausius equation and its applications.

**Ionic Equilibrium:** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis, Buffer solutions applications of buffer solutions.

**Recommended books:**

1. Lee, J.D. *Concise Inorganic Chemistry*, Pearson Education 2010.
2. *Selected Topics in inorganic Chemistry*, Madan, Tuli
3. Singh J., Yadav L. D.S., *Advanced Organic Chemistry*, Pragati Edition
4. Morrison, R.N. & Boyd, R.N. *Organic Chemistry*, Pearson Education.
5. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003
6. P.C. Rakshit, *Physical Chemistry*

### Semester-III

#### Interdisciplinary Course 1 (ID-2):

#### Bimolecular Chemistry

Credits: 03

Full Marks: 100 (IA = 40 +ESE = 60);

#### Unit I: Biomolecules I

(Credit-1, 15 L× 45 minutes)

**Carbohydrates:** Introduction, classification of carbohydrates; general properties of glucose and fructose, their open chain and cyclic structure; epimers and anomers; mutarotation, structure of disacharrides (sucrose, maltose, lactose); metabolism of glucose. Detection of carbohydrates.

**Fats, oils and lipids:** Introduction to oils, fats and fatty acids; classification of lipids, common fatty acids present in oils and fats, biological importance of fatty acids and lipids, essential fatty acids:  $\omega$ -3 and  $\omega$ -6 fatty acids; mono and polyunsaturated fatty acids and their significance.

#### Unit II: Biomolecules II

(Credit-1, 15 L× 45 minutes)

**Amino acids & Proteins:** Introduction, classification of  $\alpha$ -amino acids, Zwitter ion structure and isoelectric point; single and three letters code of amino acids; essential and non-essential amino acids; introduction on peptides, hydrolysis of peptides; overview of primary, secondary, tertiary and quaternary structure of proteins; protein denaturation/renaturation.

**Enzymes:** General aspects of enzymes, nomenclature, classification and specificity, function of enzymes. factors affecting enzyme action, co-enzymes and cofactors and their role in biological reactions, enzyme regulation & drug design, Fischer's lock and key hypothesis of enzymes activity. Some common digestive enzymes, intra-cellular and extracellular enzymes. Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

#### Unit III: Bioinorganic Chemistry

(Credit-1, 15 L× 45 minutes)

Essential metal ions present in biological systems and their role, classification of elements according to their action in biological system, structure and function of biological membranes, active transport of cations across membrane, crown ether complexes of Na and K, ionophores, Sodium/Potassium pump; carbonic anhydrase and carboxypeptidase. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine; Pt-complexes as anticancer drugs, Iron and Haemoglobin.

#### Recommended books:

1. Advanced General Organic Chemistry by Sachin Kumar Ghosh
2. Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H.Freeman,2013.
3. Organometallic and Bioinorganic Chemistry by Ajay Kumar

## Semester-IV

### Interdisciplinary Course 1 (ID-3)

#### Bimolecular Chemistry

Credits: 03

Full Marks: 100 (IA = 40 +ESE = 60);

#### Unit I: Polymers

(Credit-1, 15 L× 45 minutes)

Introduction, classification of polymers (based on source and structure): cellulose, cotton, wool, silk, paper, thermosetting polymers and thermoplastic polymers. polythene, polystyrene, PAN, PVC, PTFE, synthetic rubber, Buna-S, Buna-N, Tyrelene, Glyptal, Nylon-66, Nylon-6,10, melamine, bakelite – their monomers and uses. Bio-degradable polymers, PHBV, Polyglycolic acid-Polylactic acid, Nylon2,6. Recycling of polymers and recycle codes.

#### Unit II: Medicinal Chemistry

(Credit-1, 15 L× 45 minutes)

Concepts of drugs, classification of drugs, drug discovery, drug design and drug development; analogues and pro-drugs, soft drugs, ADME; drugs and medicines, Synthesis and applications of aspirin, paracetamol, chloramphenicol, sulphonamides, elementary concept on antibiotics; broad spectrum and narrow spectrum antibiotics. Medicinal values of curcumin (haldi), azadirachtin (neem), piperine (black pepper), vitamin C and essential oils.

#### Unit III: Chemistry in everyday life

(Credit-1, 15 L× 45 minutes)

##### Cosmetics and perfumes:

A general study including uses of the following: Hair dye, hair spray, shampoo, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams).

##### Soap and detergents:

Soaps, detergents, properties of soap, soaps for different purposes- laundry soaps, toilet soaps, liquid soaps, transparent soaps, baby soaps, shaving soaps, medicated soaps. biodegradability of detergents, green detergents.

**Shampoos:** Ingredients and functions, different kinds of shampoos, Anti-dandruff, antilice, herbal and baby shampoos. Health effects of shampoos.

**Food preservatives and additives:** Classification, chemical composition and food preservation and processing. Permitted food additives and their role; antioxidants, colouring agents, sweeteners and dyes as food additives.

**Fertilizer:** General principles of plant nutrition: essential plant nutrients, functions of the essential elements, classification of commercial nitrogenous fertilizers viz. ammonium sulphate, urea, ammonia nitrate; phosphatic fertilizers viz. single super phosphate, triple superphosphate.

##### Recommended books:

1. K. J. Saunders, Organic Polymer Chemistry, An Introduction to the Organic Chemistry of Adhesives, Fibres, Paints, Plastics and Rubbers
2. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012
3. B. K. Sharma, Engineering chemistry, Krishna Prakashan Media.
4. M. Ash, I. Ash, Formulary of Detergents and Other Cleaning Agents, Chemical Publishing, 1999.
5. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
6. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut, 1996