Revised
SYLLABUS FOR
Bachelor of Science (Honours)

CHEMISTRY

THREE YEAR DEGREE COURSE
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)

COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Inorganic Chemistry I (Theory)	CHC 1.11	4
		Inorganic Chemistry I (Practical)	CHC 1.12	2
	Core 2	Physical Chemistry I (Theory)	CHC 1.21	4
		Physical Chemistry I (Practical)	CHC 1.22	2
II	Core 3	Organic Chemistry I (Theory)	CHC 2.11	4
		Organic Chemistry I (Practical)	CHC 2.12	2
	Core 4	Physical Chemistry II (Theory)	CHC 2.21	4
		Physical Chemistry II (Practical)	CHC 2.22	2
III	Core 5	Inorganic Chemistry II (Theory)	CHC 3.11	4
		Inorganic Chemistry II (Practical)	CHC 3.12	2
	Core 6	Organic Chemistry II (Theory)	CHC 3.21	4
		Organic Chemistry II (Practical)	CHC 3.22	2
	Core 7	Physical Chemistry III (Theory)	CHC 3.31	4
		Physical Chemistry III (Practical)	CHC 3.32	2
	Skill Enhancement Course 1	Pesticide Chemistry (Theory & Practical) or Fuel Chemistry (Theory & Practical)	CHS 3.11(a) CHS 3.11(b)	2
IV	Core 8	Inorganic Chemistry III (Theory)	CHC 4.11	4
		Inorganic Chemistry III (Practical)	CHC 4.12	2
	Core 9	Organic Chemistry III (Theory)	CHC 4.21	4
		Organic Chemistry III (Practical)	CHC 4.22	2
	Core 10	Physical Chemistry IV (Theory)	CHC 4.31	4
		Physical Chemistry IV (Practical)	CHC 4.32	2
	Skill Enhancement Course 2	Chemical Technology & Society (Theory & Practical) or Pharmaceutical Chemistry (Theory & Practical) or Chemistry of Cosmetics & Perfumes (Theory & Practical)	CHS 4.11(a) CHS 4.11(b) CHS 4.11(c)	2
V	Core 11	Organic Chemistry IV (Theory)	CHC 5.11	4
		Organic Chemistry IV (Practical)	CHC 5.12	2
	Core 12	Physical Chemistry V (Theory)	CHC 5.21	4
		Physical Chemistry V (Practical)	CHC 5.22	2
	Discipline Specific Elective 1	Analytical Methods in Chemistry (Theory) or Polymer Chemistry (Theory)	CHD 5.11(a) CHD 5.11(b)	4
		Analytical Methods in Chemistry (Practical) or Polymer Chemistry (Practical)	CHD 5.12(a) CHD 5.12(b)	2
	Discipline Specific Elective 2	Green Chemistry (Theory) or Novel Inorganic Solids (Theory)	CHD 5.21(a) CHD 5.21(b)	4
		Green Chemistry (Practical) or	CHD 5.22(a)	2

		Novel Inorganic Solids (Practical)	CHD 5.22(b)	
VI	Core 13	Inorganic Chemistry IV (Theory)	CHC 6.11	4
		Inorganic Chemistry IV (Practical)	CHC 6.12	2
	Core 14	Organic Chemistry V (Theory)	CHC 6.21	4
		Organic Chemistry V (Practical)	CHC 6.22	2
	Discipline Specific Elective 3	Industrial Chemicals & Environment (Theory) or Research Methodology in Chemistry (Theory)	CHD 6.11(a) CHD 6.12(b)	4
		Industrial Chemicals & Environment (Practical) or Research Methodology in Chemistry (Practical)	CHD 6.12(a) CHD 6.12(b)	2
	Discipline Specific Elective 4	Inorganic Materials of Industrial Importance (Theory) or Instrumental Method of Chemicals (Theory)	CHD 6.21(a) CHD 6.21(b)	4
		Inorganic Materials of Industrial Importance (Practical) or Instrumental Method of Chemicals (Practical)	CHD 6.22(a) CHD 6.22(b)	2

SEMESTER - I

CORE 1 (CHC 1.11)
INORGANIC CHEMISTRY-I

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Atomic Structure:** *(12 Hours)*

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de-Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Pauli's Exclusion Principle, Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. Hund's rule of maximum multiplicity, Aufbau's principle. Electronic configurations.

UNIT II **Periodicity of Elements:** *(12 Hours)*

Modern periodic law*; s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Electropositive character
(b) Atomic and Ionic radii
(c) Covalent radii
(d) Ionization enthalpy; Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
(e) Electron gain enthalpy;trends of electron gain enthalpy.
(f) Electronegativity; Pauling's/ Mulliken's electronegativity scales. Variation of electronegativity with bond order, group electronegativity.
(g) Isoelectronic species.

UNIT III **Chemical Bonding:** *(12 Hours)*

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Derivation of Madelung constant, Born-Haber cycle and its applications, Solvation energy.
(ii) *Metallic Bond:* Qualitative idea of valence bond and band theories. Conductors, Semiconductors and insulators.
(iii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding by valence bond treatment); Effects of melting, boiling points and solubility, energetics of dissolution process.
(iv) *Coordinate covalent bond;* General ideas.

UNIT IV **Chemical Bonding-II** *(12 Hours)*

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Hybridisation; types of hybridization. Energetics of hybridization, equivalent and non-equivalent hybrid orbitals, Resonance and resonance energy, Resonance structures of CO_3^{-2}, NO_3^{-}, SO_4^{-2}, SO_2, SO_3, CO_2 Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, F_2, CO, NO, and their ions; Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of

simple molecules and ions containing lone pairs and bond pairs of electrons,BeF_2, BF_3 H_3O^+, NH_3, H_2O ,H_2S, O_3, BO_3^{-3}, PCl_5,SF_4, SF_6

UNIT V **Chemical Bonding-III and Oxidation-Reduction**: *(12 Hours)*

[a] *Chemical Bonding*: Covalent character in ionic compounds, polarizing power and polarizability, consequences of polarization. Fajan's rule and its applications. Ionic character in covalent compounds: Dipole moment, Calculation of dipole moment, Percentage ionic character from dipole moment and electronegativity difference.

[b] *Oxidation-Reduction*: General concept, Electrochemical series and its applications, Hydrogen over voltage and oxygen over voltage, redox stability in water, Frost diagram (Nitrogen), Latimer diagram (chlorine in acidic and basic medium), disproportionation of H_2O_2 into O_2 and H_2O under acidic conditions and Pourbaix diagram (iron species in natural water).

Recommended Books and References:

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition,2002
6. Madan, Tuli and Malik, selected topics of inorganic, organic & physical chemistry
7. R.L. Madan Chemistry for degree Students S. Chand & Companny Ltd New Delhi

CORE 1 (CHC 1.12)
INORGANIC CHEMISTRY-I

Practical Credit: 2

Qualitative semi micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-},NH^{4+}, K^+,Pb^{2+}
Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+},Mg^{2+}

Mixtures should preferably contain one interfering anion, **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO^{2-} and NO^{3-},Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO^{3-} and Br^-, NO^{3-} and I^-.

Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Recommended Books and References:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

CORE 2 (CHC 1.21)
PHYSICAL CHEMISTRY-I

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Gaseous state-I:** *(12 Hours)*

Kinetic molecular model of a gas: 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, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. 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 and molecular basis of heat capacities

UNIT II **Gaseous state-II and Liquid state:** *(12 Hours)*

[a]Gaseous state: van der Waals equation of state, its derivation and application in explaining real gas behaviour, Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

[b]Liquid state: Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and viscosity, and their determination (Iostenioscopic method, drop weight method, Capillary rise method and the Ostwald visocometer method). Effect of addition of various solutes on surface tension and viscosity.

UNIT III **Solid state:** *(12 Hours)*

Nature of the solid state, 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, Bragg's law, determination of crystal structure (Laue's and powder pattern method). Defects in crystals. Glasses and liquid crystals.

UNIT IV **Ionic equilibria-I:** *(12 Hours)*

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; dissociation constants of mono-, di-and triprotic acids (exact treatment). Different types of salt; Salt hydrolysis-calculation of hydrolysis constant, Relation between K_a,K_b and K_w, degree of hydrolysis and pH for different salts; of (1) strong acid and weak base(2) weak acid and strong base. (Numerical problems on relavent topics)

UNIT V **Ionic equilibria-II** *(12 Hours)*

Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and their limitations. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and Bio-chemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Recommended Books and References:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University
2. 12 Press (2014).
3. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
4. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
5. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
6. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013). Madan R.L Chemistry for Degree students S. Chand & Company
7. Arun Bahl & B.S Bahl Text book of Organic Chemistry S. Chand & Company

CORE 2 (CHC 1.22)
PHYSICAL CHEMISTRY-I

Practical Credit: 2

1. **Surface tension measurements.**
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
   b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer**.
   a. Determination of viscosity of aqueous solutions of (i) ethanol and (ii) sugar at room temperature.
   b. Study the variation of viscosity of sucrose solution with the concentration of solute.
3. **pH metry**
   a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   b. Preparation of buffer solutions of different pH
      i. Sodium acetate-acetic acid
      ii. Ammonium chloride-ammonium hydroxide
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   d. Determination of dissociation constant of a weak acid.

4. Determination of the Heat of displacement.
5. Determination of the Heat of Precipitations.

Recommended Books and References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SEMESTER - II

CORE 3 (CHC 2.11)
ORGANIC CHEMISTRY- I
(Basic & Hydrocarbon)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Basics of Organic Chemistry:** *(12 Hours)*

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Homolytic and Heterolytic fission with suitable examples; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT II **Stereochemistry:** *(12 Hours)*

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

UNIT III Chemistry of Aliphatic Hydrocarbons: *(12 Hours)*

[a] Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions:

[b] Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical) 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.

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UNIT IV **Alkynes, Cycloalkanes and Conformational Analysis** *(12 Hours)*

[a] Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes

[b] Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane:

[c] Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

UNIT V **Aromatic Hydrocarbons** (12 Hours)

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and

Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Recommended Books and References:

1. Morrison, R. N. & 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. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
5. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

CORE 3 (CHC 2.12)
ORGANIC CHEMISTRY- I

Practical Credit: 2

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Recommended Books and References:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CORE 4 (CHC 2.21)
PHYSICAL CHEMISTRY- II
(Thermodynamic and its Application)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Chemical Thermodynamics-I:** *(12 Hours)*

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, 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.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

UNIT II **Chemical Thermodynamics-II:** *(12 Hours)*

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

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

UNIT III **Free Energy Functions and Systems of Variable Composition:** *(12 Hours)*

[a]Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

[b]Systems of Variable Composition: Partial molar quantities; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

UNIT IV **Chemical Equilibrium:** *(12 Hours)*

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants *Kp*, *Kc* and *Kx*. Le Chatelier principle (quantitative treatment);

UNIT V **Solutions and Colligative Properties:** *(12 Hours)*

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic criteria for ideal solution. 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] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Recommended Books and References:

1. Peter, A. & Paula, J. de. *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
3. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
4. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
6. Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
7. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series (2006).

CORE 4 (CHC 2.22)
PHYSICAL CHEMISTRY- II

Practical Credit: 2

(a) Determination of enthalpy of hydration of copper sulphate.
(b) Study of the solubility of benzoic acid in water and determination of ΔH.
(c) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
(d) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
(e) Calculation of the enthalpy of ionization of ethanoic acid.
(f) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
(e) *Any other experiment carried out in the class.*

Recommended Books and References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).

SEMESTER - III

CORE 5 (CHC 3.11)
INORGANIC CHEMISTRY-II
(s- & p- Blocks elements)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **General Principles of Metallurgy:** *(6 Hours)*
Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic process, Parking process, van Arkel-de Boer process and Mond's process, Zone refining, oxidative process, Amalgamation process, Poling process.

UNIT II **Acids and Bases:** *(8 Hours)*
Arrhenius concept of acids and bases, Brönsted-Lowry concept of acids-bases, Lux-Flood concept of acids –bases, solvent systems, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept and its limitations, Pearsons classification of Lewis acids and Lewis bases, Hard and Soft Acids and Bases (HSAB) Principle and applications.

UNIT III **Chemistry of *s* and *p* Block Elements:** *(30 Hours)*
Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy, catenation, isomorphism. Complex formation tendency of *s* and *p* block elements. Hydrides and their classification-ionic, covalent and interstitial.

UNIT IV **Chemistry of *s* and *p* Block Elements:** *(8 Hours)*
Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, borohydrides (diborane), silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine, Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and properties of halogens

UNIT V **Noble Gases and Inorganic Polymers:** *(8 Hours)*
Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation, properties and structures of XeF_2, XeF_4 , XeF_6 ,XeO_3, $XeOF_4$ and $XeOF_2$; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2 and XeF_4). Molecular shapes of noble gas compounds (VSEPR theory).
Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes.

Recommended Books and References:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed. Pearson, 2010. 19
7. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

CORE 5 (CHC 3.12)
INORGANIC CHEMISTRY-II

Practical Credit: 2

(a) Inorganic preparations

(i) Cuprous Chloride, Cu2Cl2
(ii) Preparation of Manganese(III) phosphate, MnPO4.H2O
(iii) Preparation of Aluminium potassium sulphate KAl(SO4)2.12H2O (Potash alum) or Chrome alum.
(iv) Preparation of potassium dichromate.
(v) Preparation of Mohr's salt.
(vi) Preparation of Ferrous sulphate.
(vii) Preparation of Magnesiul sulphate.

(b) Iodometric / Iodimetric Titrations

(i) Estimation of Cu (II) using $K_2Cr_2O_7$ and sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of available chlorine in bleaching powder iodometrically.
(*more practicals based on the availability of chemicals****)***

Recommended Books and References:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

CORE 6 (CHC 3.21)
ORGANIC CHEMISTRY-II
(Oxygen containing functional groups)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Chemistry of Halogenated Hydrocarbons:** *(12 Hours)*

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

UNIT II **Alcohols, Phenols:** *(12 Hours)*

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols; Preparation and properties of glycols: Oxidation by periodic acid and lead tetra-acetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

UNIT III **Ethers, Epoxides and Sulphur containing compounds:** *(12 Hours)*

Ethers: Preparation and reactions with acids

Epoxides: Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4

Preparation and reactions of thiols, thioethers and sulphonic acids.

UNIT IV **Carbonyl Compounds:** *(12 Hours)*

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH4,NaBH4, MPV. Addition reactions of unsaturated carbonyl compounds: Michael addition.

UNIT V **Carboxylic Acids and their Derivatives:** *(12 Hours)*

Preparation, physical properties and reactions of monocarboxylic acids: Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Simple reactions of dicarboxylic acids and hydroxy acids; maleic and fumaric acids.

Recommended Books and References:

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. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

CORE 6 (CHC 3.22)
ORGANIC CHEMISTRY-II

Practical Credit: 2

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
   i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p* toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:
      a. Using conventional method. b. Using green approach
   ii. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, pcresol) by Schotten-Baumann reaction.
   iv. Bromination of any one of the following:
      a. Acetanilide by conventional methods
      b. Acetanilide using green approach (Bromate-bromide method)
   v. Nitration of any one of the following:
      a. Acetanilide/nitrobenzene by conventional method
      b. Salicylic acid by green approach (using ceric ammonium nitrate).
   vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
   vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

   The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Recommended Books and References:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000). 22
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CORE 7 (CHC 3.31)
PHYSICAL CHEMISTRY-III
(Phase Equilibria and Chemical Kinetics)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Phase Equilibria-I** *(12 Hours)*

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, Reduced phase rule (definition), phase diagram for one component systems, (H_2O system) with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, KI-H_2O system congruent Mg-Zn system and incongruent melting points. NaCl-H_2O system

UNIT II **Phase Equilibria-II** *(12 Hours)*

Two component system of solid solution (Pb-Ag) Three component systems, water-chloroform-acetic acid system, triangular plots.

Binary solutions: 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. Nernst distribution law: its derivation and applications.

UNIT III **Chemical Kinetics:***(12 Hours)*

Order and molecularity of a reaction, factors affecting rate of reaction, determination of rate laws, derivation of integrated rate law expression upto second order reactions. Determination of order of reaction (integrated, differential, graphical and half life period method) up to first order reactions, experimental methods of the determination of rate laws.

UNIT IV **Chemical Kinetics** *(12 Hours)*

Kinetics of complex reactions; Opposing reactions, parallel reactions,consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms),chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Activated complex Theory (Erying equation)

UNIT V **Catalysis and Surface chemistry:** *(12 Hours)*

[a] Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

[b] Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state. Factors affecting adsorption, Freundlich adsorption isotherm derivation, Langmuir adsorption (eliminating idea only)

Recommended Books and References:

1. Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (201 Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
6. Ball, D. W. *Physical Chemistry* Cengage India (2012).
7. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
8. Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill (2011).
9. Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill (2009).

CORE 7 (CHC 3.32)
PHYSICAL CHEMISTRY-III

Practical Credit: 2

I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.
II. Distribution of acetic/ benzoic acid between water and cyclohexane
III. Study the kinetics of the following reactions.
a. Acid hydrolysis of methyl acetate with hydrochloric acid.
b. Saponification of ethyl acetate.
c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.
IV. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
V. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
   a. simple eutectic and
   b. congruently melting systems.

Recommended Books and References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SEMESTER - IV

CORE 8 (CHC 4.11)
INORGANIC CHEMISTRY-III
(Coordination Chemistry)

Theory Credit:4 *Teaching Hours: 60*

UNIT I **Coordination Chemistry-I** *(12 Hours)*
IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes. Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding.

UNIT II **Coordination Chemistry:** *(12 Hours)*
Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

UNIT III **Transition Elements:** *(12 Hours)*
General group trends with special reference to electronic configuration: atomic and ionic radii, colouration, variable valency, magnetic, catalytic properties, ability to form alloys, interstitial compounds and ability to form complexes. Differences between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

UNIT IV **Lanthanoids and Actinoids:** *(12 Hours)*
Introduction, Electronic configuration, oxidation states, ionic radii, colour, complex formation tendency, spectral and magnetic properties, lanthanide contraction: Causes and consequences, separation of lanthanides (ion-exchange method and from monazite sand). Comparison of lanthanides and actinides, chemistry of separation of Np, Pu and Am from U. Preparation, reactions, structure and uses of uranium hexafluoride.

UNIT V **Bioinorganic Chemistry:** *(12 Hours)*
Essential and trace elements in biological system. Sodium/Potassium pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems; Storage and transfer of iron. Metalloporphyrins (chlorophyll), heme-proteins (Haemoglobin, Myoglobin) and crown-ethers. Biological role of alkaline earth metal ions with reference to Ca^{+2}.

Recommended Books and References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
2. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
4. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
5. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

CORE 8 (CHC 4.12)
INORGANIC CHEMISTRY-III

Practical Credit: 2

Gravimetric Analysis:
i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

Inorganic Preparations:
i. Tetraamminecopper (II) sulphate, $[Cu(NH3)_4]SO_4.H_2O$
ii. Tetraamminecarbonatocobalt (III) ion
iii. Potassium tris(oxalate)ferrate(III)
iv. Sodium ferrioxalate or sdium trioxalato Ferrate.
v. Cuprammonium sulphate or tetraamminocupric sulphate

Recommended Books and References:
1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

CORE 9 (CHC 4.21)
ORGANIC CHEMISTRY-III
(Heterocyclic Compound)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Nitrogen Containing Functional Groups:** *(12 Hours)*
Preparation and important reactions of nitro and compounds, 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 between 1°, 2°and 3°amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications

UNIT II **Polynuclear Hydrocarbons:** *(12 Hours)*
Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene.

UNIT III **Heterocyclic Compounds:** *(12 Hours)*
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, Knorr quinoline synthesis, Bischler-Napieralski reaction,

UNIT IV **Alkaloids:** *(12 Hours)*
Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation

and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

UNIT V **Terpenes:** *(12 Hours)*
Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α-terpineol.

Recommended Books and References:

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
9. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan

CORE 9 (CHC 4.22)
ORGANIC CHEMISTRY-III

Practical Credit: 2

1 Purification of organic compounds by crystallization using the following solvents:
a. Water b. Alcohol c. Alcohol-Water
2. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
3. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
4. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
5. Chromatography
   a. Separation of a mixture of two amino acids by ascending paper chromatography
   b. Separation of a mixture of two sugars by ascending paper chromatography
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Recommended Books and References:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

CORE 10 (CHC 4.31)
PHYSICAL CHEMISTRY-IV
(Electrochemistry-I, Quantum Chemistry-I & Spectroscopy-I)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Conductance-I:** *(12 Hours)*
Arrhenius theory of electrolytic dissociation and its limitations. Conduction in metals and in electrolyte solutions, electrolysis, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Measurement of conductance, Kohlrausch law of independent migration of ions. Ostwald`s dilution law, its uses and limitations, Debye-Hückel-Onsager equation. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transport numbers using Hittorf and Moving Boundary methods.

UNIT II **Electrochemistry-I:** *(12 Hours)*
Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Electrolytic and Galvanic cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Polarization, decomposition potential, overvoltage, polarography, corrosion.

UNIT III **Quantum Chemistry-I:** *(12 Hours)*
Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-1 D-box" quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

UNIT IV **Molecular Spectroscopy-I:** *(12 Hours)*
Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppen-heimer approximation.
Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear tri-atomic molecules, isotopic substitution.
Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.
Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.
Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

UNIT V **Electrical & Magnetic Properties of Atoms and Molecules:** *(12 Hours)*
Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation,Debye equation, dependence of polarizability on frequency, bond moments Dipole moment, molecular polarizabilities and their measurements. Dielectric polarization and dielectric constant, electric polarization of molecules, determination of dielectric constant, determination of dipole moments,

molar refraction and molar polarization. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Recommended Books and References:

1. Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
3. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., *Physical Chemistry 5th Ed.,* Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
6. Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry 4th Ed.,* John Wiley & Sons, Inc. (2005).
8. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
9. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
10. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
11. Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press (2015).
12. Lowe, J. P. & Peterson, K. *Quantum Chemistry*

CORE 10 (CHC 4.32)
PHYSICAL CHEMISTRY-IV

Practical Credit: 2

1. Conductometry

I. Determination of cell constant
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
III. Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Mixture of strong acid and weak acid vs. strong base
   iv. Strong acid vs. weak base

2. Potentiometry

I. Perform the following potentiometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Dibasic acid vs. strong base
   iv. Potassium dichromate vs. Mohr's salt

3. Determination of the heat of solution of solid calcium chloride by the Born-Haber cycle.

4. Determination of the molecular weight by Rast's method.

5. Verification of Hardy-Schulze law: Preparation and coagulation of arsenic sulphide (As_2S_3) sol using NaCl, $BaCl_2$ and $AlCl_3$ solutions.

6. To study the kinetics of iodination of acetone.

7. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)^{2+}$

(ii) $Cu^{2+}(aq) + n NH_3 \rightarrow Cu(NH_3)_n$

Any other experiment carried out in the class.

Recommended Books and References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SEMESTER - V

CORE 11 (CHC 5.11)
ORGANIC CHEMISTRY-IV
(Biomolecules)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Nucleic Acids:** *(12 Hours)*
Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

UNIT II **Amino Acids, Peptides and Proteins:** *(12 Hours)*
Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*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 III **Enzymes:** *(12 Hours)*
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).

UNIT IV **Lipids:** *(12 Hours)*
Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number. Rancidity.

UNIT V **Pharmaceutical Compounds: Structure and Importance:** *(12 Hours)*
Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of vitamin C and antacid (ranitidine).

Recommended Books and References:

1. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistr*y. 6th Ed. W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IV Edition.* W.H. Freean and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry.* XXVIII edition. Lange Medical Books/ McGraw-Hill.

CORE 11 (CHC 5.12)
ORGANIC CHEMISTRY-IV

Practical Credit: 2

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Recommended Books and References:

1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
2. Arthur, I. V. *Quantitative Organic Analysis,* Pearson.

CORE 12 (CHC 5.21)
PHYSICAL CHEMISTRY V
(Electrochemistry-II, Quantum Chemistry-II & Spectroscopy-II)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **A. Conductance-II:** *(12 Hours)*
Theory of strong electrolytes, Relaxation effect, Electrophoretic effect, Wien effect, Debye-Falkenhagen effect, Walden's rules. Activity coefficients of electrolytes, Mean Ionic activity coefficients, Ionic strength, Concentration cells with and without transference, liquid junction potential; Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT II **Electrochemistry-II:** *(12 Hours)*
Types of electrodes: Metal-metal ion electrodes, metal-metal insoluble salt electrodes, metal-amalgam electrodes, redox electrodes, calomel-electrode. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes, Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). The structures of electrified interfaces, The Helmholtz-Perrin model, Stern model; Electrocatalysis.

UNIT III **Quantum Chemistry-II:** *(12 Hours)*
Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems; Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2.

UNIT IV **Molecular Spectroscopy-II:** *(12 Hours)*

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transitions of polyenes using free electron model. Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

UNIT V **Photochemistry:** *(12 Hours)*

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Recommended Books and References:

1. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
3. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
4. Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press (2015).
5. Lowe, J. P. & Peterson, K. *Quantum Chemistry*

CORE 12 (CHC 5.22)
PHYSICAL CHEMISTRY V

Practical Credit: 2

1. Colourimetry

I. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration
II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
III. Study the kinetics of iodination of propanone in acidic medium.
IV. Determine the amount of iron present in a sample using 1,10-phenathroline.
V. Determine the dissociation constant of an indicator (phenolphthalein).
VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
VII. Analysis of the given vibration-rotation spectrum of HCl(g)

2. UV/Visible spectroscopy

I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λmax values. Calculate the energies of the two transitions in different units (J molecule-1, kJ mol-1, cm-1, eV).
II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

3. Determine the Heat of Formation of Magnesium Oxide.
4. Heating and Cooling Curve of Sodium Thiosulfate.

5. Determination of the Phase Diagram or three component system (ethyl acetate-ethyl alcohol-water).
6. Determination of the Phase Diagram for three component system (acetic acid-chloroform-water).
7. To study the effect of electrolyte and non-Electrolyte solutes on the freezing point depression of water.
8. To determine the partial molar volumes of sodium chloride solution.
9. Catalytic Decomposition of Hydrogen Peroxide on Metal Oxide Catalysts.
10. To find the critical point for colloidal mixtures composed of different types of starches.

Recommended Books and References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SEMESTER - VI

CORE 13 (CHC 6.11)
INORGANIC CHEMISTRY-IV
(Organometallic Chemistry)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Theoretical Principles in Qualitative Analysis (H_2S Scheme):** *(12 Hours)*
Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

UNIT II **Organometallic Compounds:** *(12 Hours)*
Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. 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).

UNIT III **Organometallic Compounds:** *(12 Hours)*
Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkylaluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures.
Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

UNIT IV **Reaction Kinetics and Mechanism:** *(12 Hours)*
Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

UNIT V **Catalysis by Organometallic Compounds:** (12 Hours)
Study of the following industrial processes and their mechanism:
1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

Recommended Books and References:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall,1996.
2. Cotton, F.A.G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India,

3. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.,* Harper Collins 1993, Pearson,2006.
4. Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
5. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.,* John Wiley and Sons, NY, 1994.
6. Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements*, *Elsevier 2nd Ed,*1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
7. Lee, J.D. *Concise Inorganic Chemistry 5th Ed.,* John Wiley and sons 2008.
8. Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
9. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press,1994.
10. Basolo, F. & Pearson, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.,* John Wiley & Sons Inc; NY.
11. Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
12. Miessler, G. L. & Tarr, D.A. *Inorganic Chemistry 4th Ed.,* Pearson, 2010.
13. Collman, J. P. *et al. Principles and Applications of Organotr Chemistry*. Mill Valley, CA: University Science Books, 1987.

CORE 13 (CHC 6.12)
INORGANIC CHEMISTRY-IV

Practical Credit: 2

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.

Preparation of inorganic compound

i. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λmax of the complex.
ii. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Recommended Books and References:

1. Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla. Pearson Education, 2002.
2. Marr & Rockett *Practical Inorganic Chemistry*. John Wiley & Sons 1972.

CORE14 (CHC 6.21)
ORGANIC CHEMISTRY-V
(Organic spectroscopy)

Theory Credit: 4 *Teaching Hours: 60*

UNIT I **Organic Spectroscopy-I:** *(12 Hours)*

UV Spectroscopy: Types of electronic transitions, λ max, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ max for the following systems: α, β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes:

alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes.

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 IR absorptions; Fingerprint region and its significance; application in functional group analysis.

UNIT II **Organic Spectroscopy-II:** *(12 Hours)*

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

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UNIT III **Carbohydrates:** *(12 Hours)*

Occurrence, classification and their biological importance. Monosaccharides: Constitution of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose.

UNIT IV **Dyes:** *(12 Hours)*

Classification, Colour and constitution; Mordant and Vat Dyes;

Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin.

UNIT V **Polymers:** *(12 Hours)*

Number average molecular weight, Weight average molecular weight, Polydispersity Index. Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegradable with examples.

Recommended Books and References:

1. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
5. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
7. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
9. Kemp, W. *Organic Spectroscopy*, Palgrave.

10. Pavia, D. L. *et al. Introduction to Spectroscopy* 5th Ed. Cengage Learning India Ed. (2015).

CORE14 (CHC 6.22)
ORGANIC CHEMISTRY-V

Practical Credit: 2

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

Recommended Books and References:

1. Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

DISCIPLINE SPECIFIC ELECTIVE

DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.11(a))
ANALYTICAL METHODS IN CHEMISTRY

Theory Credit: 4 *Teaching Hours: 60*

Qualitative and quantitative aspects of analysis: *(5 Lectures)*
evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data.

Optical methods of analysis: *(25 Lectures)*
Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;
Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.
Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction, Techniques for the quantitative estimation of trace level of metal ions from water samples.

Thermal methods of analysis: *(5 Lectures)*
Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Electro analytical methods: *(10 Lectures)*
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Separation techniques: *(15 Lectures)*
Solvent extraction: Classification, principle and efficiency of the technique.
Mechanism of extraction: extraction by solvation and chelation.
Technique of extraction: batch, continuous and counter current extractions.
Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.
Chromatography: Classification, principle and efficiency of the technique.
Mechanism of separation: adsorption, partition & ion exchange.
Development of chromatograms: frontal, elution and displacement methods.
Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.
Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR.

Recommended Books and References:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
7. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.12(a))
ANALYTICAL METHODS IN CHEMISTRY

Practical Credit: 2

1. Separation Techniques

1. Chromatography:
(a) Separation of mixtures
  (i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
  (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

2. Solvent Extractions:

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the $Ni2^{+-}$ DMG complex in chloroform and determine its concentration by spectrophotometry.
(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.

5. Analysis of soil:
(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:
(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of metal ions from their binary mixture.
(iii) Separation of amino acids from organic acids by ion exchange chromatography.

Recommended Books and References:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.

5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.

DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.11(b))
POLYMER CHEMISTRY

Theory Credit: 4

DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.12(b))
POLYMER CHEMISTRY

Practical Credit: 2

DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.21(a))
GREEN CHEMISTRY

Theory Credit: 4 *Teaching Hours: 60*

Introduction to Green Chemistry *(4 Hours)*
What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

Principles of Green Chemistry and Designing a Chemical synthesis *(30 Hours)*
Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

- Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy.
- Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, solventless processes, immobilized solvents and how to compare greenness of solvents.
- Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
- Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas

Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol), minimization, simplification, substitution, moderation and limitation.

- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Examples of Green Synthesis/ Reactions and some real world cases *(16 Hours)*

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
3. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
4. Designing of Environmentally safe marine antifoulant.
5. Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Future Trends in Green Chemistry *(10 Hours)*

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C_2S_3); Green chemistry in sustainable development.

Recommended Books and References:

1. Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
5. Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.22(a))
GREEN CHEMISTRY

Practical Credit: 2 *Teaching Hours: 60*

1. Safer starting materials

- Preparation and characterization of nanoparticles of gold using tea leaves.

2. Using renewable resources

- Preparation of biodiesel from vegetable/ waste cooking oil.

3. Avoiding waste

Principle of atom economy.

- Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
- Preparation of propene by two methods can be studied

(I) Triethylamine ion + OH^- → propene + trimethylpropene + water
(II) 1-propanol H_2SO_4/ propene + water

- Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

4. Use of enzymes as catalysts

- Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

5. Alternative Green solvents

Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice. Mechanochemical solvent free synthesis of azomethines

6. Alternative sources of energy

- Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
- Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Recommended Books and References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN 978-93-81141-55-7 (2013).
5. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).
6. Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).
7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition,2010.
8. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach,* W.B. Saunders, 1995.

DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.21(b))
NOVEL INORGANIC SOLIDS

Theory Credit: 4

DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.22(b))
NOVEL INORGANIC SOLIDS

Practical Credit: 2

DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.11(a))
INDUSTRIAL CHEMICALS AND ENVIRONMENT

Theory Credit: 4 *Teaching Hours: 60*

Industrial Gases *(10 Hours)*
Industrial Gases*:* Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Industrial Metallurgy *(4 Hours)*
Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

Environment and its segments *(30 Hours)*
Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur
Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, Photochemical smog: its constituents and photochemistry. Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures. Greenhouse effect and Global warming, Ozone depletion.
Water Pollution: Hydrological cycle, 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, 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.

Energy & Environment *(10 Hours)*
Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.
Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis *(6 Hours)*
Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Recommended Books and References:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
8. G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
9. A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).

DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.12(a))
INDUSTRIAL CHEMICALS & ENVIRONMENT

Practical Credit: 2

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3 2-, HCO_{3-}) using double titration method.
7. Measurement of dissolved CO_2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Recommended Books and References:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.11(b))
RESEARCH METHODOLOGY IN CHEMISTRY (THEORY)

Theory Credit: 4

DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.12(b))
RESEARCH METHODOLOGY IN CHEMISTRY (PRACTICAL)

Practical Credit: 2

DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.21(a))
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

Theory Credit: 4 *Teaching Hours: 60*

Silicate Industries *(16 Hours)*
Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.
Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Fertilizers: *(8 Hours)*
Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Surface Coatings: *(10 Hours)*
Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

Batteries: *(6 Hours)*
Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

Alloys: *(10 Hours)*
Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

Catalysis: *(6 Hours)*
General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.
Phase transfer catalysts, application of zeolites as catalysts.

Chemical explosives: *(4 Hours)*
Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

Recommended Books and References:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics,* Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: *Engineering Chemistry,* Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry,* Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).

DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.22(a))
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

Practical Credit: 2 *Teaching Hours: 60*

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

Recommended Books and References:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics,* Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: *Engineering Chemistry,* Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry,* Vikas Publications, New Delhi. Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).

DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.21(b))
INSTRUMENTAL METHOD OF CHEMICALS (THEORY)

Theory Credit: 4

DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.22(b))
INSTRUMENTAL METHOD OF CHEMICALS (PRACTICAL)

Practical Credit: 2

SKILL ENHANCEMENT COURSE

SKILL ENHANCEMENT COURSE 1 (CHS 3.11(a))
PESTICIDE CHEMISTRY

Credit: 2 *Teaching Hours: 30*

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones Chloranil), Anilides (Alachlor and Butachlor).

Practical

1 To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
2 Preparation of simple organophosphates, phosphonates and thiophosphates

Recommended Books and References:

1. Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New York, 1978.

SKILL ENHANCEMENT COURSE 1 (CHS 3.11(b))
FUEL CHEMISTRY

Credit: 2 *Teaching Hours: 30*

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Recommended Books and References:

1. Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).

SKILL ENHANCEMENT COURSE 2 (CHS 4.11(A))
CHEMICAL TECHNOLOGY & SOCIETY

Credit: 2 *Teaching Hours: 30*

Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.

Society

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants); energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.

Recommended Books and References:

1. John W. Hill, Terry W. McCreary & Doris K. Kolb, *Chemistry for changing times* 13th Ed, Prentice-Hall (2012).

SKILL ENHANCEMENT COURSE 2 (CHS 4.11(b))
PHARMACEUTICAL CHEMISTRY

Credit: 2 *Teaching Hours: 30*

Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Practical

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

Recommended Books and References:

1. Patrick, G. L. *Introduction to Medicinal Chemistry, Oxford University* Press, UK, 2013.
2. Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry,* Vallabh Prakashan, Pitampura, New Delhi, 2012.
3. Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

SKILL ENHANCEMENT COURSE 2 (CHS 4.11(c))
CHEMISTRY OF COSMETICS & PERFUMES

Credit: 2 *Teaching Hours: 30*

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Practical

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

Recommended Books and References:

1. Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).