Department of Chemistry, KSCJ
BSc Honours Syllabus (Choice Based Credits System)

Semester	Course Opted	Course Name	Name of Paper	Credits
I	Ability Enhancement Compulsory Course-I	English Communications/ Environmental science	-	2
	Core Course -I	Inorganic Chemistry	Atomic structure, periodicity of elements, chemical bonding, oxidation and reduction	4
	Core Course-I Practical	Inorganic Chemistry Lab-I	-	2
	Core Course -II	Physical Chemistry- I	States of matter & Ionic equilibria	4
	Core Course-II Practical	Physical Chemistry- I LAB	-	2
	Generic Elective -1	GE-1	-	4 // 5
	Generic Elective -1 Practical/Tutorial		-	2//1
II	Ability Enhancement Compulsory course-II	English Communications/ Environmental science	-	2
	Core Course -III	Organic Chemistry-I	Basic & Hydrocarbons	4
	Core Course-III Practical	Organic Chemistry-I LAB	-	2
	Core course -IV	Physical Chemistry-II	Chemical Thermodynamics & its application	4
	Core Course-IV Practical	Physical Chemistry-II LAB	-	2
	Generic Elective -2	GE-2	-	4 // 5
	Generic Elective -2 Practical/Tutorial		-	2//1
III	Core Course -V	Inorganic Chemistry-II	Metallurgical processes, Acids and Bases, s- & p- blocks elements, noble Gases and inorganic polymers	4
	Core Course-V Practical	Inorganic Chemistry-II LAB	-	2
	Core Course -VI	Organic Chemistry-II	Oxygen containing functional groups	4
	Core Course-VI Practical	Organic Chemistry-II LAB	-	2
	Core Course -VII	Physical Chemistry-III	Phase equilibria and chemical kinetics	4
	Core Course-VII Practical	Physical Chemistry-III LAB	-	2
	Skill Enhancement Course -1	SEC-1	-	2
	Generic Elective -3	GE-3	-	4//5
	Generic Elective -3 Practical/Tutorial		-	2//1

IV	Core Course -VIII	Inorganic Chemistry-III	Co-ordination chemistry, d & f blocks elements and Bioinorganic chemistry	4
	Core Course-VIII Practical	Inorganic Chemistry-III LAB	-	2
	Core course -IX	Organic Chemistry-III	Heterocyclic chemistry	4
	Core Course-IX Practical	Organic Chemistry-III LAB	-	2
	Core Course -X	Physical Chemistry-IV	Electrochemistry	4
	Core Course-X Practical	Physical Chemistry-IV LAB	-	2
	Skill Enhancement Course -2	SEC-2	-	2
	Generic Elective -4	GE-4	-	4//5
	Generic Elective -4 Practical/Tutorial		-	2//1
V	Core Course -XI	Organic Chemistry-IV	Biomolecules	4
	Core Course-XI Practical	Organic Chemistry-IV LAB	-	2
	Core Course -XII	Physical Chemistry-V	Quantum chemistry spectroscopy	4
	Core Course-XII Practical	Physical Chemistry-V LAB	-	2
	Discipline Specific Elective -1	DSE-1	-	4
	Discipline Specific Elective -1 Practical/tutorial	DSE-1 Lab	-	2
	Discipline Specific Elective -2	DSE-2	-	4
	Discipline Specific Elective -2 Practical/tutorial	DSE-2 Lab	-	2
VI	Core Course -XIII	Inorganic Chemistry-IV	Organo metallic compounds, Kinetics and reaction mechanism	4
	Core Course-XIII Practical	Inorganic Chemistry-IV LAB	-	2
	Core Course -XIV	Organic Chemistry-V	Organic spectroscopy	4
	Core Course-XIV Practical	Organic Chemistry-V LAB	-	2
	Discipline Specific Elective -3	DSE-3	-	4
	Discipline Specific Elective -3 Practical/tutorial	DSE-3 Lab	-	2
	Discipline Specific Elective -3	DSE-3	-	4
	Discipline Specific Elective -3 Practical/tutorial	DSE-3 Lab	-	2
Total credits			-	140

CORE COURSE
(HONOURS IN CHEMISTRY)

THEORY & PRACTICAL

Semester I

CHEMISTRY-C I: INORGANIC CHEMISTRY-I (Atomic structure, Periodicity of Elements, Chemical bonding, Oxidation and Reduction)
(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Atomic Structure: (12 Lectures)
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-2: Periodicity of Elements: (12 Lectures)
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-3: Chemical Bonding-I: (12 Lectures)
(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.

Unit-4: Chemical Bonding-II: (12 Lectures)

(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-5: Chemical Bonding-III; Oxidation and Reduction: (12 Lectures)

[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).

Reference Books:

1. B. R. Puri, L. R. Sharma, and K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone.
2. W.U.Malik, G. D.Tuli, & R.D.Madan, *Selected Topics in Inorganic Chemistry*, S. Chand & Company Ltd.
3. Advanced inorganic chemistry S. Chand & Company Ltd. Vol. I and II by Satya Prakash, G.D Tuli, S.K Basu, R.D Madan.
4. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
5. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry*Oxford, 1970
6. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
7. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
8. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition,2002
9. Madan, Tuli and Malik, selected topics of inorganic, organic & physical chemistry
   R.L Madan Chemistry for degree Students, S.Chand & Companny Ltd New Delhi.

CHEMISTRY LAB- C I LAB:

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, anthranillic acid) and external indicator.

Reference text:

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

CHEMISTRY -C II: PHYSICAL CHEMISTRY-I (States of matter & ionic equilibria)
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit-1:Gaseous state-I:(12 Lectures)
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-2:Gaseous state-II andLiquid state:(12 Lectures)
[a]Gaseous state:
Vander 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(Capillary rise method and the Ostwald viscometer method). Effect of addition of various solutes on surface tension and viscosity.

Unit-3:Solid state:(12 Lectures)
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-4:Ionic equilibria-I:(12 Lectures)
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 tri protic 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 relevant topics)

Unit-5:Ionic equilibria-II:(12 Lectures)
Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and their limitations. Buffer solutions; derivation of Henderson equation, calculation of pH of buffer mixtures, buffer capacity, buffer index, buffer action and its applications, Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Reference Books:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University 12Press (2014).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013).

CHEMISTRY LAB-C II LAB

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. pHmetry

   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.

Any other experiment carried out in the class.

Reference Books

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

CHEMISTRY-C III: ORGANIC CHEMISTRY- I (Basic & Hydrocarbon)

(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1 : Basics of Organic Chemistry: (12 Lectures)

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-2: Stereochemistry: (12 Lectures)

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-3: Chemistry of Aliphatic Hydrocarbons :(12 Lectures)

[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-4: Alkynes, Cycloalkanes and Conformational Analysis (12 Lectures)

[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-5: Aromatic Hydrocarbons (12 Lectures)

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.

Reference Books:

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.

CHEMISTRY LAB-C III LAB

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)

Reference Books

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).

CHEMISTRY -C IV: PHYSICAL CHEMISTRY- II
(Chemical thermodynamic and its application)

(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Chemical Thermodynamics-I:(12 Lectures)
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 and irreversible 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-2: Chemical Thermodynamics-II (12 Lectures)
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 heat summation, calculation of bond energy and bond dissociation energy from thermochemical data, effect of temperature(Kirchhoff's equations) and pressure on enthalpy of reactions.

Unit-3: Free Energy Functions and Systems of Variable Composition:(12 Lectures)
[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-4: Chemical Equilibrium:(12 Lectures)
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 K_p, K_c and K_x. Le-Chatelier principle(quantitative treatment);

Unit-5: Solutions and Colligative Properties:(12 Lectures)
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.

Reference Books

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 McGraw Hill (2010).
7. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series (2006).

CHEMISTRY LAB- C IV LAB

(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.

Any other experiment carried out in the class.

Reference Books

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

CHEMISTRY-C V: INORGANIC CHEMISTRY-II (Metallurgical processes, Acids and Bases, s- & p- blocks elements, Noble Gases and Inorganic Polymers)

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit-1: General Principles of Metallurgy:(12 Lectures)
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-2: Acids and Bases : (12 Lectures)
Arrhenius concept of acids and bases, Brönsted-Lowry concept of acids-bases, Lux-Flood concept of acids –bases, Usanovich concept, solvent systems, relative strength of acids, types of acid-base reactions, leveling and differentiating solvents, Amphiprotic substances, 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-3: Chemistry of *s* and *p* Block Elements-I: (12 Lectures)
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-4: Chemistry of *s* and *p* Block Elements-II: (12 Lectures)
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-5: Noble Gases and Inorganic Polymers: (12 Lectures)
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.

Reference Books:

1. W. U. Malik, G.D.Tuli, & R.D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand & Company Ltd.
2. B. R. Puri, L. R. Sharma, and K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone
3. W.U.Malik, G.D.Tuli, & R.D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand & Company Ltd.
4. Advanced inorganic chemistry S. Chand & Company Ltd. Vol. I and II by Satya Prakash, G.D Tuli, S.K Basu, R.D Madan.

5. W.U. Malik, G.D. Tuli, & R.D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand & Company Ltd.
6. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
7. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
8. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
9. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
10. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
11. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed. Pearson, 2010.
12. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

CHEMISTRY LAB-C V LAB

(a) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of potassium chromate.
(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.
(iv) Preparation of potassium dichromate.
(v) Preparation of Mohr's salt.
(vi) Preparation of Ferrous sulphate.
(vii) Preparation of Magnesium 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**)

Reference Books:

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

CHEMISTRY-C VI: ORGANIC CHEMISTRY-II (Oxygen containing functional groups)
(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1:Chemistry of Halogenated Hydrocarbons: (12 Lectures)
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-2:Alcohols, Phenols,: (12 Lectures)
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-3: Ethers , Epoxides and Sulphur containing compounds: (12 Lectures)
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-4:Carbonyl Compounds: (12 Lectures)
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-5:Carboxylic Acids and their Derivatives: (12 Lectures)
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 ,

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. 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.

CHEMISTRY LAB- C VI LAB

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.

Reference Books

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 OrganicChemistry, 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).

CHEMISTRY-C VII: PHYSICAL CHEMISTRY-III (Phase equilibria and chemical kinetics)

(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Phase Equilibria-I:(12 Lectures)
Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule. Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapoure quilibria, 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-2: Phase Equilibria-II:(12 Lectures) 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 non-ideal), azeotropes, Lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Unit-3: Chemical Kinetics I: (12 Lectures)
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 and half life period method) up to first order reactions, experimental methods of the determination of rate laws.

Unit-4: Chemical Kinetics II: (12 Lectures)
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-5: Catalysis andSurface chemistry:(12 Lectures)
[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)

Reference Books:

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 (2011).
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).

CHEMISTRY PRACTICAL-C VII LAB

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 methylacetate.

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.

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Reference Books:

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

CHEMISTRY-VIII: INORGANIC CHEMISTRY-III (Co-ordination chemistry, d & f blocks elements and Bioinorganic chemistry)

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit-1: Coordination Chemistry-I: (12 Lectures)
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-2: Coordination Chemistry-II: (12 Lectures)
Crystal field theory, crystal field splitting of d-orbitals in octahedral and tetrahedral complexes, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt), applications of crystal field theory, Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

Unit-3: Transition Elements: (12 Lectures)
General group trends with special reference to electronic configuration: atomic and ionic radii, colouration, variable valency, magnetic properties, 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-4: Lanthanoids and Actinoids: (12 Lectures)
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-5: Bioinorganic Chemistry: (12 Lectures)
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}.

Reference Books:

1. B. R. Puri, L. R. Sharma, and K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone.
2. W.U.Malik, G.D. Tuli, & R. D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand & Company Ltd.
3.Advanced inorganic chemistry S. Chand & Company Ltd. Vol. I and II by Satya Prakash, G.D Tuli, S.K Basu, R.D Madan.
4. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
5. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
6. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
7. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
8. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley &Sons, NY, 1967.
9. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

CHEMISTRY-C VIII LAB

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, $[Cu(NH_3)_4]SO_4.H_2O$
(ii) Tetraamminecarbonatocobalt (III) ion
(iii) Potassium tris (oxalate)ferrate(III)
(iv) Sodium ferrioxalate or sodium trioxalato Ferrate.
(v) Cuprammonium sulphate or tetraamminocupric sulphate

Reference Book:

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

CHEMISTRY-C IX: ORGANIC CHEMISTRY-III (Heterocyclic compound)
(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Nitrogen Containing Functional Groups:(12 Lectures)
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-2:Polynuclear Hydrocarbons: (12 Lectures)
Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene;

Unit-3:Heterocyclic Compounds :(12 Lectures)
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-4:Alkaloids :(12 Lectures)
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-5:Terpenes: (12 Lectures)
Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral,Neral and α-terpineol.

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* JohnWelly & 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

CHEMISTRY PRACTICAL-C IX LAB

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)

Reference Books

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)

CHEMISTRY-C X: PHYSICAL CHEMISTRY-IV (Electrochemistry-I, Quantum Chemistry-I & Spectroscopy-I)
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit-1: Conductance-I:(12 Lectures)
Arrhenius theory of electrolytic dissociation and its limitations. Conductivity: equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. 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-2: Electrochemistry-I: (12 Lectures)
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-3: Quantum Chemistry-I: (12 Lectures)
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-4: Molecular Spectroscopy-I:(12 Lectures)
Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.
Rotational spectroscopy: Spectra of diatomic molecule ,Selection rules, intensities of spectral lines, determination of bond lengths in polyatomic molecules
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, modes of vibration, concept of group frequencies.

Unit-5:Electrical& Magnetic Properties of Atoms and Molecules: (12 Lectures)
Basic ideas of electrostatics, Clausius-Mosotti equation, Lorenz-Laurentz equation, Debye equation, bond moments Dipole moment and molecular polarizabilities. Dielectric polarization and dielectric constant, determination of dielectric constant, dipole moments and molar polarization. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Reference Books:

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).
   Silbey, R. J.; Alberty, R. A. &Bawendi, M. G. *Physical Chemistry 4th Ed.,* JohnWiley & Sons, Inc. (2005).
7. Banwell, C. N. &McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).
8. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
9. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
10. Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications,* CambridgeUniversity Press (2015).
11. Lowe, J. P. & Peterson, K. *Quantum Chemistry*

CHEMISTRY PRACTICAL-C X LAB

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) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

Any other experiment carried out in the class.

Reference Books:

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 Chemistry8th 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

CHEMISTRY-C XI: ORGANIC CHEMISTRY-IV (Biomolecules)

(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Nucleic Acids :(12 Lectures)
Components of nucleic acids, Nucleosides and nucleotides;Structure, synthesis : Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Unit-2: Amino Acids, Peptides and Proteins: (12 Lectures)
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-3: Enzymes:(12 Lectures)
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-4: Lipids:(12 Lectures)
Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Rancidity.

Unit-5: Pharmaceutical Compounds: Structure and Importance:(12 Lectures)
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).

Reference Books:

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. Freeman 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.

CHEMISTRY PRACTICAL-C XI LAB

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.

Reference Books:

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

CHEMISTRY-C XII: PHYSICAL CHEMISTRY V
(Electrochemistry-II, Quantum Chemistry-II & Spectroscopy-II)
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit-1:A. Conductance-II:(12 Lectures)
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-2:Electrochemistry-II: (12 Lectures)
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 and quinhydrone electrode, Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Structures of electrified interfaces: The Helmholtz-Perrin model, Electrocatalysis.

Unit-3: Quantum Chemistry-II: (12 Lectures)
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-4: Molecular Spectroscopy-II:(12 Lectures)
Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.
Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation.
Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession. spin-spin coupling, high and low resolution spectra
Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

Unit-5: Photochemistry: (12 Lectures)
Light absorption by solutions: Beer-Lambert law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, examples of low and high quantum yields, photochemical rate law, kinetics of photochemical reactions (hydrogen-chlorine and hydrogen-bromine reactions), energy transfer in photochemical reactions(photosensitization and quenching), photostationary states, chemiluminescence.

Reference Books:

1. Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
2. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
3. Barrow, G. M., *Physical Chemistry 5th Ed.*, Tata McGraw Hill: New Delhi (2006).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
5. Banwell, C. N. &McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).
6. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
7. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
8. Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press (2015).
9. Lowe, J. P. & Peterson, K. *Quantum Chemistry*

CHEMISTRY PRACTICAL-C XII LAB

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 sodiumhydroxide.

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. Determination of transition temperature of $MnCI_24H_2O$.

4. Determination of the Phase Diagram for three component system (ethyl acetate-ethyl alcohol-water).

5. Determination of the Phase Diagram for three component system (acetic acid-chloroform-water).

6. Determination of coordination number of Cu^{2+} in copper-ammonia complex by partition method.

7. To determine the partial molar volumes of sodium chloride solution.

8. Catalytic Decomposition of Hydrogen Peroxide on Metal Oxide Catalysts

9. To find the critical point for colloidal mixtures composed of different types of starches.

Reference Books

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

CHEMISTRY-C XIII: INORGANIC CHEMISTRY-IV (Organo metallic compounds, Kinetics and reaction mechanism)

(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Organometallic Compounds-I: (12 Lectures)

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-2: Organometallic Compounds-II: (12 Lectures)

***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-3: Organometallic Compounds-III: (12 Lectures)

Coordinative unsaturation, oxidative addition reactions, insertion reactions; reactions of coordinated ligand and activation of small molecules by complexation;

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.
6. Monsanto acetic acid synthesis.
7. Alkene polymerization by Ziegler-Natta catalyst.

Unit-4: Kinetics and reaction mechanisms - I (12 Lectures)

Introduction to inorganic reaction mechanisms. Thermodynamic and Kinetic stability; Factors affecting the stability of complexes in solutions. Mechanism of substitution in octahedral complexes;Unimolecular nucleophilic substitution (S_N1) and bimolecular nucleophilic substitution(S_N2) mechanism. Types of intermediates formed during S_N1 and S_N2 reactions; Acid hydrolysis when the inert ligand is a pi-donor (OH^-, NH_3 etc.) Interpretation of lability and inertness of transition metal complexes by valence bond theory and crystal field theory.

Unit-5: Kinetics and reaction mechanisms - II (12 Lectures)

Lability of non-transition metal complexes. Kinetics of octahedral substitution, Ligand field effects and reaction rates.

Square planar complexes: Three ways to bring about substitution reactions in square planar complexes. Mechanism and rate law of nucleophilic substitution in square planar complexes. Factors affecting the rate of substitution reactions. Trans- effect, application of trans effect. Theories to explain trans effect by Electrostatic polarization and pi – bonding theory.

Reference Books:

1. B. R. Puri, L. R. Sharma, and K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone.
2. W.U.Malik, G.D. Tuli, & R. D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand & Company Ltd.
3. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall,1996.
4. Cotton, F.A.G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;*Wiley India,
5. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles ofStructure and Reactivity 4th Ed.*, Harper Collins 1993, Pearson,2006.
6. Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
7. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.*, John Wiley and Sons, NY, 1994.
8. Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements*, *Elsevier 2nd Ed*,1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
9. Lee, J.D. *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons 2008.
10. Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
11. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press,1994.
12. Basolo, F. & Pearson, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.*, John Wiley & Sons Inc; NY.
13. Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
14. Miessler, G. L. & Tarr, D.A. *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
15. Collman, J. P. *et al. Principles and Applications of Organotr Chemistry*. Mill Valley, CA: University Science Books, 1987.

CHEMISTRY PRACTICAL-C XIII LAB

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 λ-max 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.

Reference Books

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

CHEMISTRY-C XIV: ORGANIC CHEMISTRY-V (Organic spectroscopy)

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit-1: Organic Spectroscopy-I: (12 Lectures)
UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax 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-2: Organic Spectroscopy-II: (12 Lectures)
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-3: Carbohydrates: (12 Lectures)
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-4: Dyes: (12 Lectures)
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-5: Polymers: (12 Lectures)
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.

Reference Books:

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 AgeInternational (P) Ltd. Pub.
5. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural 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).

CHEMISTRY PRACTICAL-C XIV LAB

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 mono-functional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bi-functional 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.

Reference Books:

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 OrganicChemistry, 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).

CHEMISTRY-DSE I-IV (ELECTIVES)

1. CHEMISTRY-DSE: ANALYTICAL METHODS IN CHEMISTRY
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit-1:(12 Lectures)

Qualitative and quantitative aspects of analysis:

Evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q andt test, rejection of data.

Unit-2:(12 Lectures)

Optical methods of analysis-I:

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;

Unit-3:(12 Lectures)

Optical methods of analysis-II:

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 isotopesubstitution.

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 quantitativeestimation of trace level of metal ions from water samples.

Unit-4:(12 Lectures)

(a) Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation.Techniques for quantitative estimation of Ca and Mg from their mixture.

(b) Electroanalytical methods:

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.

Unit-5:(12 Lectures)

(a) Separation techniques:

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.

(b) 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.

Reference Books:

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.

PRACTICALS- DSE LAB: ANALYTICAL METHODS IN CHEMISTRY
60 Lectures

1. **Separation Techniques**
   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 Ni^{2+}-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 photometrictechniques.
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.

Reference Books:

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.

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2. CHEMISTRY-DSE: GREEN CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit-1 :Introduction to Green Chemistryand twelve principles of Green chemistry (12 Lectures)

What is Green Chemistry? Need for Green Chemistry.Goals of Green Chemistry.
Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.
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.

Unit-2: Green solvents (11 lectures)

Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, solventless processes, immobilized solventsand 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.

Unit-3: Designing Greener Processes (11 lectures)

Prevention/ minimization of hazardous/ toxic products reducing toxicity.risk = (function) hazard × exposure; waste or pollution prevention hierarchy.
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.

Unit-4: Some Compounds of Green synthesis/reactions (15 Lectures)

Green Synthesis of the following compounds:adipic acid, catechol (alternative to Strecker synthesis)
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
Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
Designing of Environmentally safe marine antifoulant.
An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Unit-5: Future Trends in Green Chemistry(11 Lectures)

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development, Green Chemistry versus Environment.

Reference Books:

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.

CHEMISTRY PRACTICAL - DSE LAB: GREEN CHEMISTRY
60 Lectures

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.
(i) Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
(ii) Preparation of propene by two methods can be studied
(a) Triethylamine ion + OH^- → propene + trimethylpropene + water
(b) 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
(i) Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
(ii) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, OxfordUniversity 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.

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3. CHEMISTRY-DSE: INDUSTRIAL CHEMICALS AND ENVIRONMENT
(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: (12 Lectures)

(a) 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.

(b) Industrial Metallurgy:

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

Unit-2: (12 Lectures)

Environment and its segments-I:

Ecosystems: Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, Photochemicalsmog: 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 Globalwarming, Ozone depletion.

Unit-3: (12 Lectures)

Environment and its segments-II:

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).

Unit-4: (12 Lectures)

Environment and its segments-III:

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.

Unit-5: (12 Lectures)

(a) Energy &Environment:

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.

(b) Biocatalysis:

Introduction to biocatalysis: Importance in “Green Chemistry” and Chemical Industry.

Reference Books:

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

CHEMISTRY PRACTICAL - DSE LAB: INDUSTRIAL CHEMICALS & ENVIRONMENT

60 Lectures

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 (AgNO3 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.

Reference Books:

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.

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4. CHEMISTRY-DSE: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

(Credits: Theory-04, Practicals-02)Theory: 60 Lectures

Unit-1: Silicate Industries(12 Lectures)

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.

Unit-2: Fertilizers and Batteries:(12 Lectures)

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Primary and secondary batteries, battery components and their role, Characteristics of Battery.Working of following batteries: Pb acid, Li-Battery.Fuel cells, Solar cell and polymer cell.

Unit-3: Surface Coatings:(12 Lectures)

Objectives of coatings surfaces, classification of surfacecoatings. Paints and pigments-formulation, composition and related properties. Oil paint, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels,emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plasticpaint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolyticand electroless), metal spraying and anodizing.

Unit-4: Alloys and Cements:(12 Lectures)

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurizationdephosphorisation) and surface treatment (heat treatment,nitriding, carburizing).

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

Unit-5: Catalysis and Chemical explosives:(12 Lectures)

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

Origin of explosive properties in organic compounds, preparation and explosive properties of leadazide, PETN, cyclonite (RDX).

Reference Books:

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*, DhanpatRai& 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).

PRACTICALS-DSE LAB: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

60 Lectures

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).

Reference Books:

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*, DhanpatRai& 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).

Skill Enhancement Course(SEC)
(Credit: 02 each)

1. PESTICIDE CHEMISTRY
(Credits: 02) 30 Lectures

Unit-1: (15 Lectures)
General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship.

Unit-2: (15 Lectures)
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).

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

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

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2. FUEL CHEMISTRY
(Credits: 02)30 Lectures

Unit-1: **(15 Lectures)**
Review of energy sources (renewable and non-renewable). Classification of fuels and theircalorific 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.

Unit-2: (15 Lectures)
Petroleum and Petrochemical Industry:
Composition of crude petroleum, Refining and different types of petroleum products. 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, Isoprene, Butadiene and itsderivatives .
Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.

Reference Books:

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).

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3. CHEMICAL TECHNOLOGY & SOCIETY
(Credits: 02) Theory: 30 Lectures

Unit-1: Chemical Technology(15 Lectures)

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.

Unit-2: Society(15 Lectures)

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.

Reference Book:

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

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4. PHARMACEUTICAL CHEMISTRY
(Credits: 02)Theory: 30 Lectures

Unit-1: Drugs & Pharmaceuticals(15 Lectures)

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 agent (Sulphonamides and Sulphacetamide); antiviral agents (Acyclovir).

Unit-2:Fermentation(15 Lectures)

Fermentation: Preparation of Ethyl alcohol.

Central Nervous System agents (Phenobarbital and Diazepam),Cardiovascular (Glyceryltrinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin .

Vitamin B_2, Vitamin B_{12} and Vitamin C.

Practicals

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

Reference Books:

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.

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5. CHEMISTRY OF COSMETICS & PERFUMES

(Credits: 02) 30 Lectures

Unit-1(15 Lectures)

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.

Unit-2(15 Lectures)

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.

Practicals

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.

Reference Books:

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).

CHEMISTRY
GENERIC ELECTIVE

GENERIC ELECTIVE: 1
THEORY
CONCEPTUAL ORGANIC CHEMISTRY
(Credits: Theory-4, Practicals-2)
Lectures: 60

Unit-1 Fundamentals of Organic Chemistry (12 Lectures)

Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Hybridization : Structure and shape of simple molecules CH_4, NH_3, C_2H_4, C_2H_2.

Reactive Intermediates: Nucleophiles and electrophiles, Carbocations , Carbanions and free radicals. Aromaticity: Benzenoids and Hückel's rule.

Unit-2 Stereochemistry (12 Lectures)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations, Conformation and Configuration.

Geometrical Isomerism: Requirements for a molecule to show geometrical isomerism, Cis-Trans , E & Z notation along with CIP rules for geometrical isomers.

Optical Isomerism: Optical activity, chirality, enantiomerism, diastereoisomerism, racemic mixtures, resolution. Relative and absolute configuration: D/L nomenclature system for configuration of carbohydrates. Threo & Erythro designation. R and S - configuration (upto two chiral centres).

Unit-3: Addition Reactions (12 Lectures)

Alkenes and Alkynes: Hydrogenation, addition of halogens, Hydrohalogenation (Markovnikov's and anti-Markovnikov's addition), hydration, hydroxylation, hydroboration-oxidation, ozonolysis. Reactivity of alkenes vs akynes

Aldehydes and ketones: (formaldehyde, acetaldehyde, benzaldehyde, acetone) Addition of sodium bisulphite, hydrogen cyanide and alcohols. Addition- elimination reactions with ammonia and its derivatives.
Name Reactions: Aldol, cross Aldol, Cannizzaro, cross Cannizzaro, Claisen,

Unit-4: Substitution & Elimination Reactions (12 Lectures)

Free radical substitution reactions: halogenations of alkanes, mechanism of halogenations
Name Reactions: Wurtz reaction, Kolbes reaction, Corey -House reaction.

Nucleophilic substitution reactions: Alkyl halides-substitution of halogen by some common nucleophile, mechanism of SN^1 and SN^2 reactions.

Elimination Reactions:
Alkyl halides (dehydrohalogenation, Saytzeff's rule), vicinal dihalides (dehalogenation),
Alcohols (dehydration), Elimination vs substitution.

Unit-5: Electrophilic Substitution, Oxidation & Reduction Reactions (12 Lectures)

Electrophilic Substitution Reactions:
Aromatic compounds: General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation), ortho/para & meta-director, directive influence of substituents.

Oxidation Reaction:
Aromatic side chain (Alkyl benzene): Oxidation with potassium permanganate, potassium dichromate.

Reduction Reactions:
Simple carboxylic acids and its derivatives: Lithium aluminium hydride, sodium-ethanol and Rosenmund reduction.

Recommended Texts:

1. I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
2. R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Pearson Education.
3. Arun Bahl and B. S. Bahl : *Advanced Organic Chemistry,* S. Chand
4. Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
5. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*; Wiley: London, 1994.
6. T. W. Graham Solomon's *Organic Chemistry,* John Wiley and Sons.
7. P.S. Kalsi, *Stereochemistry, Conformation and Mechanism,* John Wiley and Sons.
8. D. Nasipuri, *Stereochemistry of Organic Compounds,* New Age International Publishers.
9. Madan, Tuli and Malik, *Selected topics of Inorganic, Organic &Physical chemistry*
10. R.L. Madan *Chemistry for Degree Students,* S.Chand & Company Ltd
11. O.P. Agarwal *Organic Chemistry Reaction and Reagents* Goel Publishing House, Meerut

CHEMISTRY- GENERIC ELECTIVE PRACTICAl-1

GE-PRACTICAL-1

Qualitative semi micro analysis of mixtures containing 2 anions and 2 cations and 1 interfering radical. 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-},SO_4^{2-}, CH_3COO^-, F-,Cl-, Br-, I-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-},NH^4+, K+,Pb2+, Cu2+, Cd2+, Bi3+, Sn2+, Sb3+, Fe3+, Al3+,, Cr3+, Zn2+, Mn2+, Co2+, Ni2+, Ba2+,Sr2+, Ca2+,Mg2+

Reference text:

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

GENERIC ELECTIVE- 2

THEORY

BIOCHEMISTRY, BIO-INORGANIC AND ENVIRONMENTAL CHEMISTRY
(Credits: Theory-4, Practicals-2)
Lectures: 60

Unit-1: Carbohydrates (12 Lectures)
Classification of carbohydrates, reducing and non-reducing sugars, General properties of Glucose, open chain structure. Epimers, mutarotation and anomers.
Structure of glucose. Haworth projections. structure of disachharides (sucrose, maltose) and polysachharides (starch and cellulose) excluding their structure elucidation.

Unit-2: Amino Acids, Peptides and Proteins (12 Lectures)
Classification *of* Amino Acids, Zwitterion structure and Isoelectric point.
Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Unit-3: Lipids (12 Lectures)
Introduction to lipids, classification.
Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number.Biological importance of triglycerides, phospholipids, glycolipids.

Unit-4: Bioinorganic Chemistry (12 Lectures)
Essential and trace elements in biological systems, Metalloporphyrins, chlorophyll, heme proteins (hemoglobin, myoglobin); role of cobalt in vitamin B_{12}; Enzymes; Metalloenzymes(Zn) and their characteristics and functions; Non-complexing cations in biochemical processes(Na and K), Role of metals and non-metals in metabolism; metal and non-metal deficiency and toxicity.
Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+}. Nitrogen fixation.

Unit-5: Environmental Chemistry (12 Lectures)
Composition of the atmosphere, photochemical reactions in the atmosphere, vehicle exhausts and photochemical smog, metallic pollutants—Hg and Pb; acid rain carbon monoxide and its effects, - suspended particulate matter – size and effects on health, dual role of ozone in the atmosphere tropospheric ozone and stratospheric ozone, ozone hole, carbon dioxide and other gases responsible for global warming, Measures to control air pollution, Quality of water drinking and other purposes. Permissible limits. Common water pollutants—organic and inorganic. Heavy metals and their toxic effects. Pollution of water through use of chemical fertilizers. Measures taken to control water pollution.

Recommended Texts:

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)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.
5. Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry 7th Ed.*, W. H. Freeman.
6. Madan, Tuli and Malik, selected topics of inorganic, organic & physical chemistry

GENERIC ELECTIVE PRACTICAL-2

G.E.PRACTICAL-2

1. Detection of extra elements present in organic compound, saturation & unsaturation, Aromatic & non aromatic.
2. Functional group test for nitro, amine, amide, alcohols, carboxylic acids, phenols and carbonyl compounds

(**Reference Books)**

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).

GENERIC ELECTIVE: 3

THEORY

CHEMICAL BONDING, TRANSITION METAL & COORDINATION CHEMISTRY
(Credits: Theory-4, Practicals-2)
Lectures: 60

Unit-1: The covalent bond and the structure of molecules (12 Lectures)
Valence bond approach, Concept of resonance in various inorganic compounds,Hybridization and structure, equivalent and non-equivalent hybrid orbitals, VSEPR model for predicting shapes of molecules and ions containing lone pairs,sigma and pi bonds.

Unit-2: Molecular Orbital Approach & Intermolecular forces: (12 Lectures)
LCAO method, symmetry and overlap for s-s ,s-p and p-p combinations, MO treatment of homonuclear diatomic molecules of 2nd period (B_2, C_2 ,N_2, O_2 , F_2) and heteronuclear di-atomic molecules (CO, NO) and their ions. Intermolecular forces: van der Waals forces, Hydrogen bonding and its applications, effects of these forces on melting point, boiling point and solubility.

Unit-3: Transition Elements (3*d* series) (12 Lectures)
General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.
Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit-4: Coordination Chemistry (12 Lectures)
Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.Drawbacks of VBT. IUPAC system of nomenclature.

Unit-5: Crystal Field Theory (12 Lectures)
Crystal field effect, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for *Oh* and *Td* complexes, Tetragonal distortion of octahedral geometry.
Jahn-Teller distortion, Square planar coordination.

Suggested Texts:

1. James E. Huheey, *"Inorganic Chemistry: Principles of structure and reactivity"*, Prentice Hall, IV Edition.
2. D. S. Shriver and P.A. Atkins, *"Inorganic Chemistry"*, Oxford University Press, IV Edition.
3. Alan G. Sharpe, "*Inorganic Chemistry"*, University of Cambridge, III Edition.
4. J. D. Lee, *"A New Concise Inorganic Chemistry"*, ELBS IV Edition
5. Grey L. Miessler and Donald A. Tarr, *"Inorganic Chemistry"*, Prentice Hall, III Edition.
6. B. Douglas, D. H. McDaniel and J. J. Alexander, *"Concepts and Models of Inorganic Chemistry", John Wiley and Sons, III Edition.*
7. Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd., 2008.

GENERIC ELECTIVE: 3

PRACTICAL-3

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.

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Reference Books:

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).

GENERIC ELECTIVE: 4

THEORY

PHYSICAL CHEMISTRY FOR THE BIOSCIENCES
(Credits: Theory-4, Practicals-2)
Lectures: 60

Unit-1: Chemical Energetics (12 Lectures)

Review of the Laws of Thermodynamics.

Thermochemical equation and the laws. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.
Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.
Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit-2: Chemical Equilibrium and Chemical Kinetics (12 Lectures)

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^{o}, Le Chatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero and first order reactions. Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Unit-3: Ionic Equilibria (12 Lectures)

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

Unit-4: Phase rule and its application (12 Lectures)

Definition of the following terms:-phase, component, degrees of freedom. Derivation of the phase rule, phase equilibrium and metastable equilibrium, phase diagram involving one system (sulphur). Phase equilibra of two component systems, solid-liquid equilibra, simple eutectic Pb-Ag systems and desilverization of lead, ideal liquid mixtures, azeotropes (ethanol-water systems), Nernst distribution law (elementary idea only).

Unit-5 : Electrochemistry and Photochemistry (12 Lecturers)

Electrical transport-conduction in metals and in solutions; specific conductance and equivalent conductance, measurement of equivalent conductance, variation of specific and equivalent conductance with dilution, Kohlrausch law, Migration of ions, transport number. Arrhenius theory of electrolyte dissociation and its limitations.

Photochemistry**:** Laws of photochemistry. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions.

Recommended Texts:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry 9*th Ed., Oxford University Press (2011).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Chang, R. *Physical Chemistry for the Biosciences.* University Science Books (2005).

GENERIC ELECTIVE PRACTICAL-4
G.E-PRACTICAL-4

Titrations involving redox reactions:

1. Standardization of $KMnO_4$ solution (standard solution of Mohr's salt to be prepared).
2. Determination of concentration of Fe(II) in Mohr's salt and/or $K_2Cr_2O_7$ using diphenylamine/ N-phenylanthranilic acid as internal indicator (standard solution of $K_2Cr_2O_7$ and /or Mohr's salt to be prepared).
2. Determination of concentration of Fe(II) in $FeCl_3$ and/or $K_2Cr_2O_7$ using diphenylamine/ N-phenylanthranilic acid as internal indicator (standard solution of $K_2Cr_2O_7$ /KMnO4 to be prepared)
4. Determination of iron content in ores / alloys using appropriate redox titration.

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 $Fe(OH)_3$.

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.