TUMKUR UNIVERSITY

TUMAKURU

DEPARTMENT OF CHEMISTRY

SYLLABUS FOR

CHOICE BASED CREDIT SYSTEM SCHEME

B. Sc. CHEMISTRY

B. Sc. CHEMISTRY SYLLABUS

SEMESTER I

Theory-1.3-ATOMIC STRUCTURE, BONDING, GENERAL ORGANICCHEMISTRY & ALIPHATIC HYDROCARBONS		
Sl. No	**Topic**	**Lecture hours**
	Section-A	
1	Recapitulations of s- and p-Block elements	3
2	Atomic structure	12
3	Chemical bonding and Molecular Structure	15
	Section-B	
4	Fundamentals of Organic Chemistry	7
5	Stereochemistry-01	6
6	Introduction to green chemistry	02
7	Chromatographic techniques	04
8	Aliphatic Hydrocarbons	11
	Total hours	**60**
	Practical 1.4	**4 hours/week**

SEMESTER II

Theory-2.3-CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY		
Sl. No	**Topic**	**Lecture hours**
	Section-A	
1	Chemical Energetics	10
2	Surface chemistry	8
3	Ionic Equilibrium	12
	Section-B	
4	Aromatic Hydrocarbons	5
5	Alkyl and Aryl halides	7
6	Alcohols, Phenols and Ethers	12
7	Organometallic compounds	3
8	Active methylene compounds	3
	Total hours	**60**
	Practical 2.4	**4 hours/week**

SEMESTER III

Theory-3.3- SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY& FUNCTIONAL GROUP ORGANIC CHEMISTRY-II		
Sl. No	**Topic**	**Lecture hours**
	Section-A	
1	Solutions	8
2	Phase Equilibrium	8
3	Conductance	6
4	Electrochemistry	8
	Section-B	
5	Aldehydes and Ketones	7
6	Carboxylic acid and their derivatives	8
7	Organic Compounds containing Nitrogen	8
8	Heterocyclic Compounds	7
	Total hours	**60**
	Practical 3.4	**4 hours/week**

SEMESTER IV

Theory-4.3-COORDINATION CHEMISTRY, STATES OF MATTER &CHEMICAL KINETICS		
	Section-A	
Sl. No	**Topic**	**Lecture hours**
1	Transition elements	12
2	Coordination chemistry	8
3	Crystal Field theory	10
	Section-B	
4	Gases	8
5	Liquids	6
6	Solids	8
7	Chemical kinetics	8
	Total hours	**60**
	Practical 4.4	**4 hours/week**

OPEN ELECTIVES

Sl. No	Topic	Lecture hours
1	**Theory-4.9 A-**Pharmaceutical chemistry	**30**
2	**Theory-4.9 B-**Pesticide chemistry	**30**

SEMESTER V

Theory-5.1-ORGANIC CHEMISTRY		
Sl. No	**Topic**	**Lecture hours**
2	Stereochemistry-02	8
3	Natural Products	13
4	Industrial organic chemistry	12
5	Application of Spectroscopy to Simple Organic Molecules	12
	Total hours	**45**
	Practical 5.3A	**6 hours/week**
Theory-5.2- PHYSICAL CHEMISTRY		
Sl. No	**Topic**	**Lecture hours**
1	Quantum chemistry	20
2	Molecular Spectroscopy	18
3	Photochemistry	7
	Total hours	**45**
	Practical 5.3B	**6 hours/week**

SEMESTER VI

Theory-6.1- INORGANIC CHEMISTRY		
Sl. No	**Topic**	**Lecture hours**
1	Inorganic polymers	4
2	Organometallic Compounds	8
3	Silicates	8
4	Fertilizers	5
5	Surface coatings	5
6	General principles of Metallurgy	6
7	Alloys	5
8	Chemical explosives	4
	Total hours	**45**
	Practical 6.3A	**6 hours/week**
Theory-6.2- BIOCHEMISTRY		
Sl. No	**Topic**	**Lecture hours**
1	Lipids	4
2	Amino Acids, Peptides and Proteins	8
2	Nucleic acids	5
3	Enzymes and correlation with drug action	6
4	Bio-inorganic chemistry	6
5	Biological oxidation	4
6	Concepts of Energy in Biosystems	8
7	Hormones	2
8	Vitamins	2
	Total hours	**45**
	Practical 6.3B	**6 hours/week**

Theory - 1.3
Semester I

ATOMIC STRUCTURE, BONDING, GENERAL ORGANICCHEMISTRY & ALIPHATIC HYDROCARBONS

Theory: 4 hours/week **(Credits: 04)**

Section A: Inorganic Chemistry-1 **(30 Lectures)**

Recapitulation of *s*- and *p*-Block Elements

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales).Allotropy in C, S, and P.

Inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

(3 Lectures)

Atomic Structure: *Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.*

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it.Significance of ψ and ψ^2, Schrцdinger equation for hydrogen atom(Derivation is not expected). Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(12 Lectures)

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landй equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basisof VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination

of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s- p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

(15 Lectures)

Section B: Organic Chemistry-1 **(30 Lectures)**

Fundamentals of Organic Chemistry

Electronic effects: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Huckel's rule, Aromaticty of Pyrole and Pyridine.

(7 Lectures)

Stereochemistry-01

Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Conformational analysis: Baeyer strain theory – Ring strain in cyclopropane and cyclobutane - Conformation and configuration - Dihedral angle - Torsional strain - Conformational analysis of ethane and n-butane including energy diagrams - Conformers of glycol - Conformers of cyclohexane - Axial and equatorial bonds - Ring flipping – Conformers of mono and 1,2-disubstituted cyclohexane – Relative stability - Conformation of cyclohexane-1,4-diol. **(6 Lectures)**

Introduction to green chemistry - Principles of green chemistry and its application to the synthesis of Ibuprofen. **(2Lectures)**

Chromatographic techniques

Fundamentals of chromatography: general description, definition, terms and parameter used in chromatography, classification of chromatographic methods, criteria for selection of stationary phase, and mobile phase, nature of adsorbents, factor influencing the adsorbent, nature and type of mobile phases and stationary phases.

Thin- layer chromatography (TLC): definitions, mechanism, efficiency of TL plates, methodology-selection of stationary phase, and mobile phase, preparation of plates, spotting, development, identification and detection, reproducibility of R_F values

(4Lectures)

Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). *Preparation:*Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) *Preparation:*Acetylene from CaC_2 and conversion into higheralkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis and oxidation with hot alk. $KMnO_4$. **(11 Lectures)**

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in InorganicChemistry*, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. &Medhi, O.K. *Inorganic Chemistry:Principles of Structure and Reactivity*, Pearson Education India, 2006.
- Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
- Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. &Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

Practical 1.4: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Practicals: 4 hours/week **(Credits: 02)**

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
6. Estmination of MnO_2 in pyrolusite by titrating with $KMnO_4$

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

a)Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

b)Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

a)Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   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

Reference Books:

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

Theory – 2.3
Semester II

CHEMICAL ENERGETICS, EQUILIBRIA &FUNCTIONAL ORGANIC CHEMISTRY

Theory: 4 hours/week **(Credits: 04)**

Section A: Physical Chemistry-1 **(30 Lectures)**

Chemical Energetics

Review of I law of thermodynamics, need for II law of thermodynamics and different ways of stating II law of thermodynamics with respect to its spontaneity, spontaneous and non-spontaneous processes. Concept of entropy and its significance-illustrations for order, disorder, physical, chemical process and probability.

Heat engine: Carnot's cycle and derivation of the expression for its efficiency, problems. II law in terms of efficiency. Change in entropy in reversible and irreversible processes. Calculation of entropy changes in reversible isothermal and reversible adiabatic process. Limitations of the entropy concept and spontaneity.

Gibbs free energy: Work function, chemical potential, definition and relationship between free energy and work function. Criteria for equilibrium and spontaneous processes - problems.Gibb's-Helmoltz equation (derivation-differential form).Rate of change of free energy with respect to temperature and pressure. Temperature coefficient (mention only), van't Hoff isotherm, $\Delta G^0 = -RT\ln Kp$ and problems on this equation.

Van't Hoff reaction isochore (derivation): Clausius - Clapeyron equation (derivation). Mention its applications to ΔT_b and ΔT_f determination (derivation not required), problems on Van't Hoff isochore and Clausius - Clapeyron equation.

Qualitative treatment of Nernst heat theorem and III law of thermodynamics (statement only). Elementary concept of residual entropy. **(10 Lectures)**

Surface chemistry:

Adsorption- types of adsorption, factors affecting adsorption. Free energy change in adsorption, Adsorption isotherms – Freundlich's isotherm and Langmuir's adsorption. Derivation of Langmuir's adsorption isotherm, BET equation (derivation not required) applications.

Catalysis- types, general characteristics, homogeneous and heterogeneous catalysis. Theories of catalysis, intermediate compound formation theory and adsorption theory.Enzyme catalysis –lock and key mechanism with example. Michaelis-Menton enzyme catalytic equation, derivation of mathematical expression for the Michaelis-Menton equation. Industrial applications of enzymes and catalysts. **(8 Lectures)**

Ionic Equilibria: 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. **(12 Lectures)**

Section B: Organic Chemistry-2 **(30 Lectures)**
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aromatic hydrocarbons
Preparation of benzene, naphthalene, anthracene. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). Nitration and sulphonation of naphthalene - Polycyclic arenes as carcinogens (simple examples only). **(5 Lectures)**

Alkyl and Aryl Halides
Alkyl Halides (Upto 5 Carbons) *Preparation:* from alkenes *and* alcohols.Types of Nucleophilic Substitution SN1 & SN2 – Mechanisms, Neighbouring group participation with examples). *Reactions:* hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Substitution reactions (Williamson'sether synthesis: Elimination vs substitution.

Aryl Halides *Preparation:*(Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. **(7 Lectures)**

Alcohols, Phenols and Ethers (Upto 5 Carbons)
Alcohols: *Preparation:* Preparation of 1^o, $2^o$and 3^oalcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, With HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement (Mechanism).

Chemistry of methanol poisoning – Harmful effects of ethanol in the human body. Test for alcohols (Lucas test and Victor Meyer test). Synthesis of glycerol and chemical properties (nitration, dehydration and oxidation)

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts.*Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction(Mechanism), Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. Uses of phenol - Preparation and applications of phenolphthalein,– Reason for the colour change of phenolphthalein with pH.

Ethers and Epoxides
Ethers: Nomenclature – Isomerism - Preparation by Williamson's Synthesis. Reactions of ethers: Acidic cleavage, Claisen rearrangement with Mechanism.

Epoxides: Nomenclature– Preparation from alkenes – Ring opening reactions **(12 Lectures)**

Organometallic compounds:

Grignard reagent, organozinc and organolithium compounds – Preparation and synthetic applications **(3 Lectures)**

Active methylene compounds:

Preparation, Keto-enol tautomerism and Synthetic uses of ethylacetoacetate and diethyl melanoate. **(3 Lectures)**

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. &Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).

Practical 2.4: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Practicals: 4 hours/week **(Credits: 02)**

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*.

Ionicequilibria

pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide
(iii) Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: (Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done).

(a) Bromination of Phenol/Aniline
(b) Benzoylation of amines/phenols
(c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone
(d) Nitration of nitrobenzene

Reference Books

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbookof Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

Theory – 3.3
Semester III

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

Theory: 4 hours/week **(Credits: 04)**
Section A: Physical Chemistry-2 **(30 Lectures)**

Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions.Lever rule.Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation.Nernst distribution law and its applications, solvent extraction. **(8 Lectures)**

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium.Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

(8 Lectures)

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base). **(6 Lectures)**

Electrochemistry

Reversible and irreversible cells.Concept of EMF of a cell.Measurement of EMF of a cell.Nernst equation and its importance.Types of electrodes.Standard electrode potential.Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only). **(8 Lectures)**

Section B: Organic Chemistry-3 **(30 Lectures)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aldehydes and Ketones: Nomenclature, Preparation (Rosenmund reduction, Vilsmeyer and Etards reactions). Chemical reactions: Nucleophilic addition (addition of water, bisulphite, HCN, alcohol) - Addition-elimination reactions (hydroxyl amine, hydrazines, semicarbazide, 2, 4 - DNP and ammonia) - Oxidation (with $KMnO_4$, Tollen's reagent, Fehling's solution, Benedict's reagent, Oppenauer oxidation) – Reduction (Wolf Kishner, Clemmenson, MPV reduction) –- Aldol condensation with mechanism - Claisen Schmidt, Knoevenagel and Perkin's reactions - Mechanism of Acetal formation, Cannizarro reaction and Beckmann rearrangement, Benzoin condensation. **(7 Lectures)**

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic): *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Acidity (effect of substituent on acidity of aliphatic and aromatic carboxylic acids) Hell – Vohlard - Zelinsky Reaction, Decarboxylation, Hunsdiecker reaction

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)
Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Mechanism for acid catalysed esterification. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction.
Dicarboxylic acid: Action of heat on dicarboxylic acids (C1-C6) (Blanc's Rule)
Naturally occurring carboxylic acid, structure, sources, importance, their important reactions. (Lactic acid, citric acid, tartaric acid, pyruvic acid, niacin, cholic acid).

(8 Lectures)

Organic Compounds containing Nitrogen

Nitro compounds: Preparation of alkyl nitrites, m-dinitrobenzene and TNT - Reduction products of nitrobenzene in various media – Nef's reaction.

Amines: Nomenclature, Preparation from alkyl halides, nitro compounds, Hofmann's Bromamide reaction, Gabriel phthalmide synthesis. Chemical properties: Basicity (effect of substituents on basicity of aliphatic and aromatic amines), Carbylamine reaction, alkylation, Conversion of amine to alkene (Hofman's elimination – mechanism), acylation, reaction with nitrous acid - Distinguishing of Amines by Hofmann and Hinsberg's methods.

Diazonium salts: Preparation(Mechanism) and synthetic applications of benzene diazonium chloride – Preparation of Methyl orange - Reason for colour change with pH.

Diazocompounds: Synthesis and synthetic applications of diazomethane**.** **(8 lectures)**

Heterocyclic compounds: Introduction to heterocyclic compounds, Types, Nomenclature, Preparation and Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Furan, Pyrrole, Thiophene, and Pyridine and quinoline, Indole.

(7 Lectures)

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York (1985).
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. &Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

Practical 3.4: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II

Practicals: 4 hours/week **(Credits: 02)**

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I^-(aq) \quad I_3^-(aq)$

$Cu^{2+}(aq) + xNH_2(aq) \quad [Cu(NH_3)_x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Section B: Organic Chemistry

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.

3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a nonreducing sugar.

Reference Books:

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbookof Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

Theory – 4.3
Semester IV

COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

Theory: 4 hours/week **(Credits: 04)**

Section A: Inorganic Chemistry-3 **(30 Lectures)**

Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency (special reference to Cr, Fe, Co, Ni, Co), colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanides and actinides: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

(12 Lectures)

Coordination Chemistry

Introduction to Coordination compounds. Complex ion, ligands, co-ordination number, oxidation state of metal. IUPAC system of nomenclature. 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. **(6 Lectures)**

Crystal Field Theory

Postulates, Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry.Factors affecting the magnitude of Δ. Spectrochemical series.Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Color of transition metal complexes

Electronic spectra of transition metal complexes having d^1 and d^2 system.

Magnetic properties of low spin and high spin complexes of Fe, Co and Ni.

Ligand filed theory. Introduction and evidences for covalency in M-L bond.

(12 Lectures)

Section B: Physical Chemistry-3 **(30 Lectures)**

Gases

Introduction- Need for Maxwell-Boltzmann distribution law, mathematical expressions for both mole and molecule-explanation of the terms only.Explanation of velocity distribution curve based on this law (no derivation). Mean free path, collision frequency, collision number, definition and expressions using SI units (no derivation). Derivation of expression for *most probable speeds* from Maxwell-Boltzmann equation.Definitions and expressions for *rms velocity* and *average velocity*, relationships among them.*Problems* on speed in SI units.

Andrew's isotherm on carbon dioxide and explanation of the curves (no experimental details). Derivation of critical constants T_c, P_c and V_c from van der Waal's equation and their density for V_c. Problems on the calculation of T_c, P_c, V_c, a and b.

Law of corresponding states-statements, reduced equation of states and explanation.Joule-Thomson effect-explanation, Joule-Thomson coefficient, Inversion temperature-definition (no derivation).Their application to the liquification of air and hydrogen (by Linde's process in detail).

(8 Lectures)

Liquids

Surface tension and its determination using stalagmometer.Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer.Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

(6 Lectures)

Solids

Forms of solids.Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices.X–Ray diffraction by crystals, Bragg's law.Structures of NaCl, KCl and CsCl (qualitative treatment only).Defects in crystals.Glasses and liquid crystals.

(8 Lectures)

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, first and second order reactions (both for equal and unequal concentrations of reactants).Half–life of a reaction.General methods for determination of order of a reaction.Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

(8 Lectures)

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry,* Wiley.
- Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
- Wulfsberg, G. *Inorganic Chemistry,* Viva Books Pvt. Ltd.
- Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd., 2008.
- Concise Coordination Chemistry, R. Gurudeep,C. Ramalingam.

Practical 4.4: COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

Practical: 4 hours/week **(Credits: 02)**

Section A: Inorganic Chemistry

Semi-micro qualitative analysis using H_2S of mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+},Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+

Anions : CO_3^{2-} , S^{2-}, SO^{2-}, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-,SO_4^{2-}, PO_4^{3-}, BO_3^{3-} ,$C_2O_4^{2-}$, F^- *(Spot tests should be carried out wherever feasible)*

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given).
3. Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
4. Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbookof Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

Theory – 4.9A(OPEN ELECTIVE)
Semester IV

PHARMACEUTICAL CHEMISTRY

Theory: 2 hours/week **(Credits: 02)**

Drugs & Pharmaceuticals

Drug discovery, design and development; Basics of classification. Action of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine). **(20 Lectures)**

Fermentation

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

(10 Lectures)

Reference Books:

- G.L. Patrick: Introduction to *Medicinal Chemistry, Oxford University* Press, UK.
- Hakishan, V.K. Kapoor: *Medicinal and Pharmaceutical Chemistry,*VallabhPrakashan, Pitampura, New Delhi.
- William O. Foye, Thomas L., Lemke , David A. William: *Principles of MedicinalChemistry*, B.I. Waverly Pvt. Ltd. New Delhi.

Theory – 4.9B (OPEN ELECTIVE) **Semester IV**

PESTICIDE CHEMISTRY

Theory: 2 hours/week **(Credits: 02)**

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

(**30 Lectures**)

Reference Book:

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

Theory – 5.1
Semester V

ORGANIC CHEMISTRY

Theory: 3 hours/week **(Credits: 03)**

Stereochemistry-02

Geometrical isomerism : cis-trans, syn-anti and EZ notations - Methods of distinguishing geometrical isomers using melting point, dipole moment, solubility, cyclisation and heat of hydrogenation.

Optical isomerism: Definition – Specific rotation – Chirality and elements of symmetry – Threo and erythro; D and L; Enantiomers - Diastereomers – Optical isomerism in lactic acid, glyceraldehyde and tartaric acid - Meso compounds – Racemic mixture - Resolution methods - Optical activities in compounds without asymmetric carbon atoms (biphenyl and allenes) - DL and RS configurations – Enantiomeric excess - Asymmetric synthesis. Stereospecific and stereoselective reactions.

(8 Lectures)

Natural Products

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Terpenes: Isoprene rule – Occurrence, Classification with examples – Elucidation of structure and synthesis of citral, zingiberene, Structure of limonene, menthol, camphor, beta-carotene vitamine A and uses.

Alkaloids: Introduction, Classification, General properties – Structure and physiological functions of nicotine, quinine, coniine and piperine. Structural elucidation and synthesis of nicotine.

Pheromones: Introduction,classification,structure,sources and uses of grandisol and ombykol

(13Lectures)

Industrial organic chemistry

Synthetic dyes: Introduction and classification, colour and constitution. Synthesis of Congo Red, Malachite Green , Alizarin and Indigo.

Drugs: Chemotherapy, classification of drugs, synthesis and uses of paractomol, diclofenic, Ranitidine, sulphanilamide and chlomphenicol.

Sulphonic acids: Preparation and properties of Benzene sulphonic acid - Synthesis and application of saccharin**.**

Pesticides: General introduction to pesticides, types, Synthesis of DDT, Gammexene Chloranil Alachlor.

Cosmetics: Talcum powder, perfumes, deodorants, creams, nail polish, depilatories, turmeric and neem preparations, lipstick, rouges, eyebrow pencils & eye liners (Ingredients and functions) - Harmful effects of cosmetics.

Foods: Food additives – Food preservatives, artificial sweeteners, antioxidants (definition, examples), permitted and non-permitted food colours (name only), junk foods and chocolates - Harmful effects of these in the human body - Structure of BHT and BHA – Artificial ripening of fruits and its side effects.

(12 Lectures)

Molecular Spectroscopy and its application to Simple Organic Molecules

Introduction to UV spectroscopy. Electromagnetic radiations, electronic transitions, $л_{max}$ & $е_{max}$, chromophore, auxochrome, bathochromic and hypsochromic shifts. Woodward rules for calculating $л$ max of conjugated dienes and б,в – unsaturated carbonyl compounds.

Introduction to Infrared radiation, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Introduction to NMR spectroscopy. Basic principles of PMR. Nuclear magnetic spin quantum number I. Influence of magnetic field on the spin nuclei, spin population, saturation using radio frequency. Nuclear magnetic resonance, Chemical shift , TMS as reference, Nuclear shielding and deshielding effect. Equivalent and non-equivalent protons.Factors affecting the chemical shift values. Spin-spin splitting and coupling (qualitative only)

Application of spectral techniques for structural elucidation of some simple organic molecues.

UV-Visible: λ_{max} - UV spectra of butadiene, acetone, methyl vinyl ketone and benzene.

IR: alcohols, aldehydes, ketones, esters and acids.

NMR: PMR spectra of acetone, $CHBr_2CH_2Br$, ethyl alcohol, toluene, acetaldehyde and propanoic acid, simple aromatic systems.

(12 Lectures)

Reference Books:

- James E. Huheey, Ellen Keiter& Richard Keiter: *Inorganic Chemistry: Principles ofStructure and Reactivity*, Pearson Publication.
- G.L. Miessler& Donald A. Tarr: *Inorganic Chemistry*, Pearson Publication.
- J.D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley & Sons.
- I.L. Finar: *Organic Chemistry* (Vol. I & II), E.L.B.S.
- John R. Dyer: *Applications of Absorption Spectroscopy of Organic Compounds,* Prentice Hall.
- R.M. Silverstein, G.C. Bassler& T.C. Morrill*: Spectroscopic Identification ofOrganic Compounds*, John Wiley & Sons.
- R.T. Morrison & R.N. Boyd: *Organic Chemistry*, Prentice Hall.
- Peter Sykes: *A Guide Book to Mechanism* in *Organic Chemistry*, Orient Longman.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand.

Theory – 5.2
Semester V

PHYSICAL CHEMISTRY

Theory: 3 hours/week **(Credits: 03)**

Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrodinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrцdinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule. Schrцdinger equation, transformation to spherical polar coordinates. Separation of variables.Spherical harmonics.Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrцdinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrцdinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

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 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB).Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH).Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

(20 Lectures)

Molecular Spectroscopy (Physical Approach) :

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.
Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.
Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, 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 predissociation, calculation of electronic transitions of polyenes using free electron model.
Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.
Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

(18 Lectures)

Photochemistry

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

(7 Lectures)

Reference Books:

- Banwell, C. N. &McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
- House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).
- Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press (2015).

Practical

Practicals: 6 hours/week **(Credits: 03)**

5.3A: *Organic Chemistry*

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Reference Books:

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbookof Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

5.3B*: Physical Chemistry*

Colorimetry

I. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration
II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
III. Study the kinetics of iodination of propanone in acidic medium.
IV. Determine the amount of iron present in a sample using 1,10-phenathroline.
V. Determine the dissociation constant of an indicator (phenolphthalein).
VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
VII. Analyse the given vibration-rotation spectrum of HCl(g)
VIII. Study of kinetics of KI vs $K_2S_2O_8$ by colorimetric method
IX. Study of kinetics of oxidation of indigocarmine by chloromine-T

Conductance

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. Determination dissociation constant (Ka) of weak acids (CH_3COOH, $CH_2ClCOOH$ by conductometric method.

Potentiometry

Perform the following potentiometric titrations:

i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Potassium dichromate vs. Mohr's salt

Additional experiment:

1. Determination of transition temperature of the given salt hydrate by thermometric method

Reference Books

- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in PhysicalChemistry 8th Ed.;* McGraw-Hill: New York (2003).
- Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry 3rdEd.;* W.H. Freeman & Co.: New York (2003).

Theory – 6.1
Semester VI

INORGANIC CHEMISTRY

Theory: 3 hours/week **(Credits: 03)**

Inorganic Polymers

General properties, glass transition temperature and its determination. Phosphorous, Sulphur, Silicon and boron based polymers and its applications.

(4 Lectures)

Organometallic Compounds

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptorbehaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

(8 Lectures)

Silicates

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. Hightechnology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

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

(8 Lectures)

Fertilizers:

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

(5 Lectures)

Surface Coatings:

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

(5 Lectures)

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology. **(6 Lectures)**

Alloys:

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

(5 Lectures)

Chemical explosives:

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX).Introduction to rocket propellants.

(4 Lectures)

Reference Books:

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

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Theory – 6.2
Semester VI

BIOCHEMISTRY

Theory: 3 hours/week **(Credits: 03)**

Lipids

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, Rancidity

Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

(4 Lectures)

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis.Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$group, complexationwith Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. **(8 Lectures)**

Nucleic Acids

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation. **(5 Lectures)**

Enzymes and correlation with drug action

Mechanism of enzyme action, 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 and Non-competitive inhibition including allosteric inhibition). Drug action-receptor theory.Structure –activity relationships of drug molecules, binding role of –OH group,-NH_2 group, double bond and aromatic ring. **(6 Lectures)**

Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions

in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones). **(6 Lectures)**

Biological oxidation

Bioenergetics; energy transformations in living systems, free energy concept.Exergonic and endergonic reactions, ATP and other high energy compounds, energy coupling.

Mitochondrial electron transport chain –components, schematic representation indicating sites of ATP synthesis.Oxidative phosphorylation – Chemosmatic theory (an outline).Substrate level phosphorylation. **(4 Lectures)**

Concept of Energy in Biosystems

Calorific value of food.Standard caloric content of carbohydrates, proteins and fats.Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy,

ATP hydrolysis and free energy change.

Conversion of food into energy. Outline of catabolic pathways of Carbohydrate-Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins.Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates. **(8 Lectures)**

Hormones Introduction-General characteristics, Classification of hormones on the basis of structure.General mechanism of hormone action and second messenger - cAMP as an example.Biological importance of somatotropin, insulin, glucagon, progesterone, estrogen and androgen. **(2 Lectures)**

Vitamins Introduction-fat soluble- sources, chemical names and deficiency symptoms/syndromes, Hypervitaminosis, water-soluble – sources, deficiency manifestations and coenzyme forms. **(2 Lectures)**

Reference books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7thEd.*, W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. &Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

PRACTICALS

Practicals: 6 hours/week **(Credits: 03)**

6.3A *Inorganic Chemistry*

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)

Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or

Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}

2. Preparation of any two of the following complexes and measurement of their conductivity:
(i) tetraamminecarbonatocobalt (III) nitrate
(ii) tetraamminecopper (II) sulphate
(iii) potassium trioxalatoferrate (III) trihydrate
(iv) hexamminenickel(II) chloride
(v) Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.
3. Determination of free acidity in ammonium sulphate fertilizer.
4. Estimation of calcium in calcium ammonium nitrate fertilizer.
5. Estimation of phosphoric acid in superphosphate fertilizer.
6. Electroless metallic coatings on ceramic and plastic material.
7. Determination of composition of dolomite (by complexometric titration).
8. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
9. Analysis of Cement.
10. Preparation of pigment (zinc oxide).
11. Determination of the amount of iron in haematite
12. Determination of the amount of calcium in limestone
13. Determination of the amount of ferrous iron using 1,10-phenathroline by colorimetric method
14. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
15. Draw calibration curve (absorbance at $Л_{max}$ vs. concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
16. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.
17. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
18. Estimation of total hardness of a given sample of water by complexometric titration.
19. Determination of concentration of Na^+ and K^+ using Flame Photometry.

6.3B: ***Biochemistry***

1. Estimation of the amount of reducing sugar (glucose) by dns method
2. Estimation of the amount of creatinine by jaffe's method
3. Estimation of the amount of inorganic phosphate by fiskesubbarow method
4. Estimation of reducing sugar (glucose) by Hagedorn - Jensen's method
5. Estimation of the amount of reducing sugar (glucose) by somogy's method
6. Separation of amino acids by paper chromatography
7. To determine the concentration of glycine solution by formylation method.
8. Study of titration curve of glycine
9. Action of salivary amylase on starch
10. Effect of temperature on the action of salivary amylase on starch.
11. To determine the saponification value of an oil/fat.
12. To determine the iodine value of an oil/fat
13. Differentiate between a reducing/ nonreducing sugar.
14. Extraction of DNA from onion/cauliflower
15. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.
16. Estimation of DNA by diphenylamine method
17. Estimation of cholesterol by Zak's method.
18. Separation of proteins and nucleic acids by electrophoresis.

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