

I- Semester
CHEM/II/EC/01
Inorganic Chemistry-I-Theory

Marks [Scaled]: 100 (Internal: 25 + End Semester Exam: 75)

Credits: 3-1-0

UNIT I

Atomic Structure: de-Broglie's concept of dual character of matter; Heisenberg's Uncertainty Principle; Schrodinger wave equation (derivation not required); quantum numbers; radial and angular wave functions (derivations not required) and probability distribution curves; atomic-orbitals; shapes of *s*, *p* and *d*-orbitals.

Aufbau principle; Pauli's exclusion principle; Hund's rule of maximum multiplicity; Effective nuclear charge, shielding or screening effect.

UNIT II

(a) Periodic Properties:

General features of long form of periodic table. Detailed discussions (definition, factors affecting it and periodic trends) of the following properties of the elements, with reference to *s* & *p*- block.

(a) Atomic radii and Ionic radii (including isoelectronic species) (b) Ionization Energy, Successive ionization energies (c) Electron Affinity (d) Electronegativity .

(b) Redox - Reactions: Electronic concept of oxidation and reduction; Oxidation number, calculation of oxidation number; Calculation of Equivalent Weights of Oxidants and Reductants. Balancing of redox reactions by ion-electron methods (simple redox reactions).

UNIT III

Chemical Bonding - I:

Basic idea of ionic bond, covalent bond and coordinate bond. Ionic character in covalent compounds: Polarity of covalent bonds, Bond moment and dipole moment.

Concept of hybridization, types, orientation of hybrid orbitals; Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons taking the following examples: BeF_2 , BF_3 , SnCl_2 , NH_3 , H_2O , H_3O^+ , H_2S , PCl_3 , PCl_5 , SF_4 , SF_6 , ClF_3 , ICl_2^- .

Hydrogen bonding: types, nature, conditions for its formation. Effects of hydrogen bonding on melting and boiling points.

UNIT IV

Coordination Chemistry-I

Definition and terminology; Ligands and their classification; Werner's Theory; IUPAC nomenclature of coordination compounds; effective atomic number; Chelates and chelate effect; Isomerism in coordination compounds. Stereochemistry of complexes with coordination number 4 and 6.

UNIT V

Nuclear Chemistry and Radioactivity

Units of radioactivity; group displacement law; theory of radioactive disintegration; half-life and average-life period; radioactive equilibrium; artificial radioactivity. Neutron-proton ratio in a nucleus and its implications; packing fraction; mass defect ; Nuclear binding energy; magic number concept.

Elementary ideas of fission, fusion, controlled fission reactions and nuclear reactors (fast breeder reactor and thermal reactors).

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers & Distributors.
2. R. Gopalan, *Inorganic Chemistry* for undergraduates, University Press
3. R.L. Dutta, *Inorganic Chemistry*, Part-I Principle, The New Book Stall
4. H.J. Arnikar, *Essentials of nuclear Chemistry*, New Age International Publishers, ISBN 81-224-0712-9

Additional Books

1. W.U. Malik G.D Tuli and R.D Madan, Selected Topics in Inorganic Chemistry, S. Chand.
2. G. Wulfborg, Inorganic Chemistry, Viva books Private Limited, ISBN 81-7649-228-4
3. N.N. Greenwood and Earnshaw, Chemistry of the Elements Butterworth
4. B. Douglas, D. Mc Daniel, John Alexander, Concepts and Models of Inorganic Chemistry, John Wiley & Sons, ISBN 81-265-0911-2

CHEM/IEC/02
Inorganic Chemistry-I-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

(A)* (30 + 7 Marks)

Inorganic mixtures containing three radicals/ions to be identified from the following list:

Ag⁺, Pb²⁺, Hg²⁺, Cd²⁺, Bi³⁺, Sb³⁺, Sn²⁺, Sn⁴⁺, Fe²⁺, Al³⁺, Mn²⁺, Co²⁺, Co³⁺, Ni²⁺, Ca²⁺, Sr²⁺, Ba²⁺, Mg²⁺, K⁺, Na⁺, NH₄⁺, Cl, SO₄²⁻, CRO₄²⁻, PO₄³⁻, NO₃⁻, BO₃³⁻

(B)*Titrimetric Analysis (30 + 8 Marks)

(i) Preparation of standard solutions of different Molarity/Normality of titrants.

Acid- Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

Recommended Books

1. O.P. Pandey, D.N. Bajpaj and Giri, S. Practical Chemistry, S. Chand & Co.(2003)
2. J. Basset, R.C Danney, G.H. Jeffery and j. Mendham, Vogel's Text Book of Quantitative Inorganic Analysis, 4th ed., ELBS
3. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, ELBS

NOTE: Experiments may be added/deleted subject to the availability of facilities

II Semester
CHEM/II/EC/03
Organic Chemistry-I-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

UNIT I

Electron-displacement effects in organic molecules and the basic concept of reaction mechanism

Role of Inductive-effect, Electromeric-effect, Mesomeric-effect or Resonance, hyperconjugation, curved arrow notation, drawing electron movements with arrows, half headed and double-headed arrows, homolytic and heterolytic bond-breaking,

Types of reagents—electrophiles & nucleophiles. Energy considerations, reactive intermediates- carbocations, free-radicals, carbanions, carbenes, arynes, the stability of reaction intermediates.

Hydrogen-bonding and its effect on boiling point and solubility of organic molecules.

UNIT II

(a) Arenes and Aromaticity: Structure of benzene, molecular orbital picture of benzene, stability of benzene ring, resonance-energy, Aromaticity: the Huckel rule & its application.

(b) Aromatic Halogen Compounds: Nuclear and side-chain halogenation, electrophilic and nucleophilic substitution in aromatic halogen compounds.

UNIT III

Aldehydes and Ketones: Structure of the carbonyl group, chemical reactivity of carbonyl group, mechanism of nucleophilic additions and addition- elimination reactions with HCN, NaSO₃H, NH₂OH, NH₂-NH₂, C₆H₅NH NH₂, NH₂CONH-NH₂.

Phenol: Physical properties and acidic-character, chemical reactions.

Carboxylic acids and their derivatives: Effect of substituents on the acidity of carboxylic acid groups, methods of preparation, chemical-reactivity.

UNIT IV

Amines (Aliphatic and Aromatic): basicity and effect of substituents on basicity, chemical reactivity-acylation, action of nitrous acid, action of CS₂, carbylamine reaction, condensation with carbonyl groups and ring substitution, distinction between primary, secondary and tertiary amines.

UNIT V

(a) Nucleophilic Substitution Reactions: Nucleophile, ambident nucleophile, SN₁, SN₂, SN_i, factors affecting substitution reactions (structure of substrate, nature of nucleophile, solvent, role of leaving group), mechanism and stereochemistry of substitution reactions, difference between Nucleophile and bases.

(b) Elimination reactions (E₁, E₂): Orientation in elimination reactions (Saytzeff's and Hofmann's rule).

Recommended Books:

1. P.Y. Bruice, Organic Chemistry, Pearson Education, ISBN 81 – 7808-581-X
2. G.M. Loudon, Organic Chemistry, Oxford University Press, ISBN 0-19-511999-1
3. R.T. Morrison and R.N. Boyd, Organic Chemistry, Prentice Hall India, ISBN 81-203-0765-8
4. R.R. Gupta, M. Kumar, V. Gupta, Heterocyclic Chemistry I & II, Springer, ISBN 81-81-28-221-3

Additional Books:

1. L.G. Wade, Jr., Organic Chemistry, Pearson Education, ISBN 81-297-0248-7
2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, ISBN 0-19-580346-6.
3. TL Gilchrist, Heterocyclic Chemistry, Longman Scientific &v Technical , ISBN 0-582-01421-2.

CHEM/II/EC/04
Organic Chemistry-I-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

Qualitative Analysis (60+15 Marks): Systematic qualitative analysis of organic compounds containing one functional group.

- (a) Detection of elements (N, Cl, Br, I, S)
- (b) Detection of the following functional groups (with systematic reporting)
COOH, NH₂, NO₂, OH (phenolic) & CO (Carbonyl group) and amide
- (c) Preparation of derivatives

Recommended Books

1. O.P.Pandey, D.N. Bajpai, S. Giri, Practical Chemistry, S.Chand & Co., New Delhi
2. J.N. Gurtu & R. Kapoor, Advance Experimental Chemistry, Vol. II, S Chand & Co., New Delhi

NOTE: Experiments may be added / deleted subject to the availability of facilities

III- Semester
CHEM/III/EC/05
Physical Chemistry-I-Theory

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75) **Credits: 3-1-0**

UNIT I: Gaseous State

Kinetic Molecular model of a gas, Postulates and Derivation of Kinetic Gas Equation (KGE), Deviation from Ideal behavior (causes); Compressibility factor (Z) and its variation with pressure for different gases; Vander Waal's equation of state; Evaluation of Critical Constant from Vander Waal's equation; critical compressibility factor (Z_c), Law of Corresponding states & Boyle temperature.

UNIT II: Liquid State

Introduction, Vacancy theory of liquid, Free volume in liquid, Physical properties of liquids viz., surface tension, viscosity & refraction. Refraction Index, Specific refraction & Molar refraction (definitions only), Effect of temperature on surface tension & viscosity.

Liquid crystals – structure and types of liquid crystals (elementary discussion only).

UNIT III: Colloids and Surface Chemistry

Classification of colloids, preparation of colloids, Bredig's and condensation methods, Peptization, Optical properties of colloids-Tyndall effect. Origin of charge on colloidal particles, protective colloids, gold number.

Physisorption & chemisorptions; molar enthalpy of adsorption, Langmuir, Freundlich & Gibbs adsorption isotherms.

UNIT IV: Dissociation Equilibria

Dissociation equilibria of weak electrolytes, dissociation constant of weak acids (K_a), ionic product of water (K_w), hydrogen ion concentration and pH scale, buffer solutions and buffer activity, hydrolysis constant (K_h), derivation of hydrolysis constant between K_a , K_w and K_h , derivation of hydrolysis constant for salts of –i) strong acid and weak base, ii) weak acid and strong base and iii) weak acid and weak base, pH, buffer solutions and buffer activity & Henderson- Hasselbach equations for acidic & basic buffers.

UNIT V: Thermodynamics I

Limitations of the First Law and Need of the second law, Statements of the 2nd law; Carnot's cycle; Efficiency of Carnot's engine; Concept of Entropy; Entropy change for an Ideal gas with (i) T & V (ii) T & P & (iii) Entropy change for Reversible and Irreversible processes, Relationship between entropy (S) and probability (W).

Books Recommended:

1. Puri, Sharma, & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, Jalandhar.
2. P. C. Rakshit, Physical Chemistry, Sarat Book Distributors, Calcutta
3. A.S. Negi, S.C. Anand, A Text book of Physical Chemistry, New Age International Publishers, N. Delhi
4. P. W. Atkins, Physical Chemistry, ELBS, Oxford Univ. Press (OUP), Latest Edition.

5. N. B. Singh, S. S. Das, & Ram Ji Singh, Physical Chemistry, New Age International Publishers, N. Delhi.

CHEM/III/EC/06
Physical Chemistry-I-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) **Credits: 0-0-2**

Marks (60+15)

1. Determination of Surface tension of a field liquid by Drop number method.
2. Determination of coefficient of viscosity by Oswald's viscometer of ethanol – water system.
3. Determination of water equivalent of a calorimeter.
4. Determination of heat of neutralization of a strong acid with strong base.
5. Study of Heat of dilution of H_2SO_4 and then determination of the strength of the unknown acid.

Books Recommended

1. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books Private Limited, New Delhi
2. S. Chawla, Essentials of Experimental Engineering Chemistry, Dhanpat Rai & Co., New Delhi
3. J. B. Yadav, Advance Practical Physical Chemistry, Geol Publishing House, Meerut.

NOTE: Experiments may be added/deleted subject to the availability of chemicals/apparatus.

IV- Semester
CHEM/IV/EC/07
Analytical Chemistry-I-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

Unit-I

Safety and hygiene in the Chemistry Lab

Storage and handling of chemicals, handling of acids, ethers, toxic and poisonous chemicals, antidotes, threshold vapor concentration and First-Aid procedure. Heating methods, stirring methods and filtration techniques.

Qualitative Analysis

Common ion effect, application of solubility product and common ion effect in analytical chemistry; Interfering anions and their removal; group separation.

Unit-II

Classical separation methods:

Theories of distillation, fractional distillation, steam distillation, sublimation and zone refining. Solvent extraction: Recovery and enrichment factors. Liquid-liquid extraction. Successive extractions. Separation of mixtures. Craig method. Uses of high molecular mass amines, dithiocarbamates and Crown ethers in extraction.

Unit-III

Evaluation of experimental Data

Significant figures, rounding off of numerical expressions, types of errors: correction/minimization of errors, propagation of determinate errors, accuracy and precision, methods of their expression, difference between accuracy and precision, rejection of data, Statistical treatment of analytical data, uncertainties involve in addition, subtraction, multiplication and division, confidence limits and intervals, test of significance (the F-test and t-test).

Unit-IV

Volumetric Analysis

Terms commonly used in volumetric titrimetry (analyte, titrant, titration, equivalence point, end point, indicator), primary standard and secondary standard, expressing concentrations of standard solutions (normality, molarity, ppm), acid base titrations, redox titrations, iodimetric and iodometric titrations, theory of acid-base indicators.

Unit-V

Gravimetric Methods

Theory of precipitation and purification of precipitates, co-precipitation, post-precipitation, fractional-precipitation, chemistry of separation and estimation of ions (iron-calcium, calcium-barium and iron-copper).

Use of the following organic reagents in inorganic analysis: Oxine, 1-nitroso-2-naphthol, cupferron, dithiazone, dimethylglyoxime and rhodamine-B.

Recommended Books

1. D.A. Skoog, D.M. West and F.J. Holler, Fundamentals of Analytical Chemistry, Saunders College publishing.
2. G.D. Christian, Analytical Chemistry, New York – John Wiley
3. S.M. Khopkar, Basic Concepts of Analytical Chemistry, New Age International Publisher
4. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, Longman

Additional Books

1. J.J. Lingane, Electroanalytical Chemistry, Interscience
2. H.W. Willard, L.L. Merrit, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis, CBS Publishers & Distributors, Delhi
3. R.A. Dau and A.L. Thomas and R.P. Bauman, Advance Analytical Chemistry, McGraw Hill

CHEM/IV/EC/08
Analytical Chemistry-I-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

Marks (60+15)

1. Determination of indicator constant - colorimetry.
2. Beer's Law - Determination of concentration of solution by colorimetry.
3. Determination of pH of a given solution using glass electrode.
4. Dissociation constants of weak acid, base.
5. Determination of pH of a given buffer
6. To titrate HCl solution against NaOH solution potentiometrically and to determine the concentration of HCl in a solution
7. To titrate a solution of Fe^{2+} salt against $\text{Cr}_2\text{O}_7^{2-}$ and to determine the formal redox potential of Fe^{2+} reversible to Fe^{3+} system

Iodo / Iodimetric Titrations

- (i) Estimation of the strength of I_2 solution by using sodium thiosulphate solution(Iodi-metrically)
- (ii) Estimation of Cu(II) or $\text{K}_2\text{Cr}_2\text{O}_7$ using sodium thiosulphate(Iodometrically)
- (iii) Estimation of the percentage of available chlorine in bleaching powder(Iodometrically)

Recommended Books

1. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books Private Ltd. New Delhi
2. S. Chawla, Essentials of Experimental Engineering Chemistry, Dhanpat Rai & Co. New Delhi
3. J.B. Yadav, Advance Practical Physical Chemistry, Geol Publishing House, Meerut
4. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, Longman

NOTE: Experiments may be added/deleted subject to the availability of facilities

V Semester
CHEM/V/CC/09
Inorganic Chemistry-II-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

Unit I

Chemical Bonding-II

(i) Ionic Solids: General characteristics; Packing of ions in crystals; types of interstitial sites, limiting radius ratio values for different interstitial sites; radius ratio rule and the shape of ionic crystals; lattice energy; factors affecting the magnitude of lattice energy; Born-Haber cycle and its application, Solvation energy and solubility of ionic solids; defects in crystals and the consequences, semiconductors (n-type and p-type).

Unit II

Chemical Bonding III

Molecular orbital theory: Conditions for the combination of atomic orbital to form molecular orbital; pictorial representation of combination of atomic orbital to form various molecular orbital; Molecular orbital diagrams of simple homonuclear (H_2 , He_2 , O_2 and N_2) and heteronuclear diatomic molecules (CO and NO) and their ions.

Weak Chemical forces: van der Waals forces: dipole-dipole interactions, dipole-induced dipole interactions, Instantaneous dipole-induced dipole interactions. Effects on melting and boiling points.

Unit III

Chemistry of s and p block elements:

Study of the following compounds with emphasis on preparation, properties, structure and uses: Hydrides and carbides (ionic and covalent).

Brief explanation of Catenation and Inert pair effect, Relative stability of different oxidation states of p-block.

Oxides and oxoacids of nitrogen; Peroxo-acids of sulphur.

Inter-halogen compounds (types, structure and bonding) and pseudohalogens.

Noble Gases: Isolation and separation of noble gases by fractionation of liquid air. Clathrates. Preparations, structures and bonding of XeF_2 , XeF_4 and XeF_6 .

Unit IV

A. Acid Base Concept: Brief review of Bronsted – Lowry concept, Lewis concept and solvent system concept of acids and bases.

B. Non-Aqueous Solvents: Classification of solvents; importance of non-aqueous solvents. Reactions in liquid ammonia– (i) Neutralisation reactions, (ii) precipitation reactions, (iii) complex formation reactions, (iv) redox reactions and (v) solvolysis reactions. Action of liquid ammonia on alkali metals and alkaline-earth metals.

C. Molecular symmetry: Symmetry operations, symmetry elements and symmetry point groups of SO_2 , R_2NH , $BeCl_2$, H_2O , BF_3 , H_2O , BF_3 , H_2O_2 & NH_3 ; Rules or conditions for a molecule to form a group, Group multiplication table, sub-group, class and order of a group.

Unit V

A. Transition elements: General group trends with special reference to electronic configuration, colour, oxidation states, reducing properties and magnetic properties, ability to form complexes. Differences between the first, second and third transition series.

B. Coordination Chemistry-II

Valence Bond theory (inner and outer orbital complexes).

Crystal field theory, factors influencing the magnitude of crystal field splitting, crystal field splitting in octahedral, tetrahedral and square planar geometry. CFSE in weak and strong fields.

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers & Distributors.
2. S. Prakash, G. D. Tuli, S. K. Basu & R. D. Madan, *Advanced Inorganic Chemistry*, Vol. I & II, S. Chand & Co.
3. R. Gopalan, *Inorganic Chemistry* for undergraduates, University Press
4. R.L. Dutta, *Inorganic Chemistry*, Part-I Principle, The New Book Stall
5. J. D. Lee, *Concise Inorganic Chemistry*, ELBS.

CHEM/V/CC/10
Inorganic Chemistry-II-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

(A) Inorganic preparations (Marks 30+7)

- (i) Cuprous Chloride, Cu_2Cl_2
- (ii) Aluminium Potassium sulphate $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (Potash alum) or $\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (Chrome alum).
- (iii) Tetraammine copper (II) sulphate, $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- (iv) Potassium trisoxalatochromate (III), $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$
- (v) Micricosmic salt, $\text{Na}(\text{NH}_4)\text{HPO}_4 \cdot 4\text{H}_2\text{O}$
- (vi) Potassium chlorochromate (III), $\text{CrO}_2\text{Cl}(\text{OK})$
- (vii) Sodium cobaltinitrite $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$
- (viii) Chrome red, $\text{PbCrO}_4 \cdot \text{PbO}$

(B) Quantitative (Gravimetric) Analysis: (Marks 30+8)

- (i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.
- (ii) Estimation of sulphate as Barium sulphate / Barium as Barium sulphate.
- (iii) Estimation of iron as Fe_2O_3 by precipitating iron as $\text{Fe}(\text{OH})_3$.

NOTE: Experiments may be added/deleted subject to the availability of facilities

CHEM/CC/11
Organic Chemistry-II-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

UNIT- I

Stereochemistry of organic molecules: Concept of Isomerism, types of Isomerism.

- (a) **Geometrical Isomerism:** E & Z system of nomenclature, geometrical isomerism in oximes and alicyclic compounds.
- (b) **Optical Isomerism :** Elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, diastereo isomers, meso compounds, resolution of enantiomers, inversion and retention of configurations, Racemization. Relative and absolute configuration.
- (c) Sequence rules, D & L and R & S system of nomenclature.

UNIT -II

Conformational Isomerism: Conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono-substituted and disubstituted cyclohexane, Newman projection and Sawhorse formulae, Fischer and flying wedge formulae. Difference between configuration and conformation.

UNIT-III

- (a) **Heterocycles-I:** Introduction, preparation and electrophilic substitution reactions of pyrrole, furan and thiophene, Structure, synthesis and reactions of pyridine; comparative basicity of pyrrole/pyridine, pyrrole/pyrrolidine and pyridine/piperidine.
- (b) **Heterocycles-II:** Introduction to condensed five and six membered heterocycles, preparation of indole, quinoline and isoquinoline with special reference to Fischer indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis.

UNIT-IV

- (a) **Active Methylene Compounds:** Definition of active methylene group, examples of active methylene compounds, tautomerism, difference between tauto-merism and resonance (Keto-enol tautomerism).
- (b) Cannizzaro's reaction; acidity of α -hydrogen in carbonyl compounds, formation of enolates, aldol condensation, Perkin-reaction, benzoin condensation, Clemmensen and Wolff-Kishner reductions.

UNIT-V

- (a) **Introduction to Organic Synthesis Name Reactions :** Formation of carbon-carbon bond, electrophilic and nucleophilic carbon species, acid-assisted reaction (Friedel Crafts alkylation and acylation), base- assisted condensations (Knoevenagel, Michael, Wittig reaction, Reformatsky reaction, Claisen-Schmidt reaction, Mannich reaction); Formation and acid-assisted cleavage of acetals and ketals; mechanisms of formation and hydrolysis of esters and amides (acyclic and cyclic)

- (b) Molecular Rearrangements:** Carbocation rearrangement - pinacol-pinacolone, Wagner-Meerwein, dienone-phenol, Beckmann Wolff, Hofmann, Benzil-Benzilic acid, Fries and Claisen- rearrangements.

Recommended Books

- a. R. Bruckner, Advance Organic Chemistry; Reactions Mechanism, Academic Press an Imprint of Elsevier, ISBN 81-8147-713-8
2. PS Kalsi, Stereochemistry Conformations and Mechanisms, New Age International Publications, ISBN 81-224-0115-5.
3. P.S. Kalsi, Organic Reactions and their Mechanisms, New Age International Publishers, ISBN 978-81-224-2596-3

Additional Books

1. M.J.T. Robinson, Organic Stereochemistry, Oxford University Press, ISBN 0-19-567412-X
2. R.P. Narain, Mechanisms in Organic Chemistry, Pearson, ISBN(10): 81-224-2135-0

CHEM/V/CC/12
Organic Chemistry-II-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

A. Organic Preparations and Separations (Marks 30+8)

Preparation of the following organic compounds

1. Phthalimide
2. m-Dinitro benzene
3. Picric acid
4. Benzoic acid
5. Aspirin from methyl salicylate

B. Organic separation (Marks 30+7)

1. Separation of Binary organic mixtures based on acid-base concept
2. Determination of melting points.

NOTE: Experiments may be added/deleted subject to the availability of facilities

CHEM/CC/13
Physical Chemistry-II-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

UNIT I: Gaseous state II

Maxwell's Distribution Law of Molecular Velocities (Derivation); Evaluation of average, root mean square (rms) & Most Probable Velocities, and Average Kinetic Energy (KE) from Maxwell's law, KE as a function of Temperature; Degrees of freedom; Law of Equipartition of Energy.

UNIT II: Solid State

Space lattice and Unit cell (Definitions); Laws of Crystallography; Laws of Constancy of Interfacial angles and Rational indices; Miller indices; Law of Symmetry: Symmetry Elements in Crystals, Seven crystal systems. Bravais lattices; X-ray Diffraction by Crystals; Derivation of Bragg's equation. Experimental methods of crystal analysis; Bragg's X-ray spectrometer; The Debye-Scherrer powder method.

UNIT III: Chemical Kinetics & Catalysis

Concepts of Rate, Order and Molecularity of reaction, Effect of Temperature on Reaction Rate; Temperature Coefficient of a reaction, Arrhenius Equation; Concept of Activation energy, Collision Theory & Absolute Reaction Rate Theory. Types and characteristics of Catalysis, Enzyme catalysis; Michaelis-Menten equation; Turn over number (definition only)

UNIT IV: Thermodynamics - II

Third Law Statement; Nernst Heat Theorem; Calculation of absolute Entropy from Heat Capacity Data (up to Debye T^3 Law); Concept of Residual Entropy, Gibb's (G) and Helmholtz (A) Energy; Gibb's - Helmholtz Equation; Variation of G and A with P, V, and T.

Thermodynamics of Open System

Concepts of Partial Molar properties and Partial Molar Energy (Chemical potential), Gibbs - Duhem equation. Variation of Chemical potential with T & P.

UNIT V: Electrochemistry I

Electrical Conductance; Specific, Equivalent and Molar Conductivity; Variation of Conductance with Dilution for weak and strong electrolytes; Kohlrausch's Law of independent migration of ions.

Arrhenius theory of Electrolytic dissociation; Ostwald's dilution law, Ionic strength, Debye - Huckel - Onsager equation for strong electrolytes (derivation not required), Asymmetry effect; Electrophoretic effect. Drift Velocity, Ionic mobility and Transport number; Determination of transports number by Hittorf's and Moving boundary Method.

Books Recommended:

1. P. W. Atkins, *Physical Chemistry*, ELBS, OUP, Latest Edition.
2. T. Engel & P Reid *Thermodynamics, Statistical Thermodynamics & Kinetics*, Pearson Education Inc., New Delhi (2007/Latest Publication)
3. Puri, Sharma, & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co, Jalandhar.
4. P. C. Rakshit, *Physical Chemistry*, Sarat Book Distributors, Calcutta
5. A.S. Negi, S.C. Anand, A Text book of *Physical Chemistry*, New Age International Publishers, N. Delhi.

Additional References:

1. D. N. Bajpayee, *Advanced Physical Chemistry*, S. Chand & Co. Ltd., N. Delhi.
2. S. Glasstone, *Thermodynamics for Chemists*, East West Press, latest edition.
3. K. J. Laidler, *Chemical Kinetics*,
4. G. W. Castellan, *Physical Chemistry*, Narosa publications, latest edition

CHEM/V/CC/14
Physical Chemistry-II-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

(Marks 60+15)

1. Determination the solubility of a given salt (BaCl_2) at two temperatures (60°C and 40°C) and to determine the heat of solution
2. Determination of the solubility of benzoic acid (an organic acid) at two temperatures (50°C and room temperature); and then to determine the heat of solution of that solute.
3. Determination of the strength of the given ferrous sulphate solution potentiometrically.
4. Determination of velocity constant of the hydrolysis of methyl acetate, catalysed by an acid.
5. Determination of the strength of hydrochloric acid solution (approx. N/10) by titration against standard sodium hydroxide solution conductometrically (use oxalic acid for the standardization of sodium hydroxide conductometrically).
6. Acid-Alkali titration using potentiometer.
7. Determination of the strength of a halide solution potentiometrically using silver nitrate.
8. Conductometric titration of a weak acid and a strong base.
9. Conductometric titration of a strong acid and a weak base.

NOTE: Experiments may be added/deleted subject to the availability of chemicals/apparatus.

Books Recommended

1. B. Viswanathan and P.S. Raghavan, *Practical Physical Chemistry*, Viva Books Private Limited, New Delhi
2. S. Chawla, *Essentials of Experimental Engineering Chemistry*, Dhanpat Rai & Co., New Delhi
3. J. B. Yadav, *Advance Practical Physical Chemistry*, Geol Publishing House, Meerut.

CHEM/V/CC/15 (A)*
Analytical Chemistry (Option A)

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 4-2-0

Unit I 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.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Unit II Electrogravimetric Methods

Electrogravimetry: Principle and method. Determination of Cu. Separation of metals.

Conductometry: Principle and method. Conductance measurements. Conductometric titrations. **Coulometry:** Principle and method. Coulometric titrations.

Voltammetry

Basic principles of polarography. DC polarography: Theory and method. Current-voltage relationship. Characteristics of DME. Half-wave potential. Principle of stripping voltammetry.

Amperometry: Principle and method. Amperometric titrations.

Unit III Thermoanalytical Methods

Thermal methods of analysis: Principles and instrumentations of TGA and DTA.

Complementary nature of TGA and DTA. Differential scanning calorimeter (DTA).

Applications of thermal methods in analytical chemistry and in the study of minerals and polymers.

Unit IV:

Spectrochemical Methods:

Electronic, IR & Raman Spectra and molecular structure, Spectral data bases, quantitative calculations, Instrumentation of UV-Vis, IR & Raman Spectrometry.

Basic idea of atomic spectroscopy, Principle and instrumentation of Flame emission and Atomic absorption spectrometry, Distribution between Ground and excited states ((Maxwell-Boltzmann expression).

Unit V Analysis of Selected Materials

Analysis of milk products: Theory of the analysis of milk, butter and other dairy items.

Analysis of fats and oils. Characterization of fats and oils. Iodine value, iodine-bromine value and saponification value, and their significances. Quality control.

Books Recommended

1. A.I.Vogel, "A Textbook of Quantitative Inorganic Analysis", Longman
2. A.I.Vogel, "Text Book of Qualitative Organic Analysis", Longman
3. C.L.Wilson and D.W.Wilson, "Comprehensive Analytical Chemistry", Vol IB
4. D.A.Skoog, D.M.West and F.J.Holler, "Fundamentals of Analytical Chemistry", Saunders College publishing.
5. L.Meites,, H.C.Thomas and R.P.Bauman, "Advanced Analytical Chemsitry", McGraw Hill

References

1. R.A.Day and A.L.Underwood, "Quantitative Analysis", Prentice Hall
2. H.W.Willard, L.L.Merrit, J.A.Dean and F.A.Settle, "Instrumental Methods of Analysis", CBS Publishers & Distributors, Delhi
3. W.W.Wendlandt, "Thermal Methods of Analysis", John Wiley & Sons
4. T.Hatakeyama and F.X.Quinn, "Thermal Analysis", John Wiley & Sons
5. J.J.Lingane, "Electroanalytical Chemistry", Interscience
6. Finar, "Organic Chemistry", Vol II
7. "British Pharmacopoeia", 1988
8. "Official Methods of Analysis of AOAC, Vol 17, 1994

V Semester
CHEM/V/CC/15 (B)*
Industrial Chemistry (Option B)

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 4-2-0

Unit-I

Fertilizer

Essential nutrients (N, P, K) and their role in plants; Manufacture, important properties and uses of - Nitrogenous fertilizers (Urea, Ammonium Sulphate, Calcium Ammonium Nitrate), Phosphatic fertilizers (Calcium Superphosphate, Phosphate Slag), Potash fertilizers (Potassium nitrate) and mixed fertilizers; Biofertilizers.

Cement

Composition of Portland cement; Essential raw materials, manufacture (through wet process) and setting of cement.

Glass

Raw materials for glass manufacture, Manufacture of ordinary glass, Variety of glass (Soft glass, Hard glass, Flint glass, Jena glass, Pyrex glass, Crooke's glass, Quartz glass and Safety glass).

Unit II

Fermentation Technology

Introduction, application of fermentation-microbial biomass, microbial enzyme, transformation process, recombinant products, fermentation process, mode of operation fermentation process, the genetic improvement of product formation-mutation.

Food Technology

Introduction, food safety assurance, food chemistry-carbohydrates, proteins, lipids, minor components of foods, water in foods, food processing-fundamental of fluid flow, food preservation, food process and flowcharts, refrigerated transport of fruits and vegetables.

Unit III

Leather Industry

Curing, preservation and tanning of hides and skins, process of dehairing and dyeing, treatment of tannery effluents.

Chemical Explosives

Origin of explosive, preparation and chemistry of lead azide, nitroglycerine, nitrocellulose, TNT, Dynamite, cordite, picric acid, gunpowder, introduction to rocket propellants.

Unit IV

Coal

Origin and economics importance of coal, types analysis and composition, coal gasification, carbonisation, coal-tar based chemicals manufacture, coal mines in India.

Petroleum

Origin, refining, cracking, reforming knocking and octane number, synthetic gas, synthetic petrol. Fuel gases: Large scale production, storage, hazards and uses of coal gas, water gas, producer gas and oil gas.

Unit V

Polymer Industry

Important industrial polymers, preparation and applications-polyethylene, polyamides, PVC, polyethylmethacrylate, polyesters, polyurethanes, phenol-formaldehyde.

Textile Industry

Introduction, textile industry-role of textile designers, timing in the textile industry, designer's projection, adhesives, color-considerations in textile design techniques of forming colour combinations, changing color looks, presenting of color combinations.

Books Recommended

1. B.N. Chakraborty, Industrial Chemistry, Oxford and IBH Publishing Co., New Delhi(1981).
2. B.K. Sharma, Industrial Chemistry, Geol Publishing House, Meerut.
3. M.P. Stevens, Polymer Chemistry –An Introduction, Oxford (1990).
4. Marypaul Yates, Textiles-A hand Book for Designers, revised edition, WW. Norton and Company, New York, Lodon (1986).
5. Geofferey Cambell-Plat, Food Science and Technology, John Wiley and Sons (2009) [ISBN-978-0-632-06421-2]
6. P.F. Stanbury, Stephen J. Hall and A. Whitaker, Principles of Fermentation Technology, Butterworth-Heinemann, 2nd edition (1999) [ISBN-10: 0750645016].
7. (R.R. Puri, L.R. Sharma and K.C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers & Distributors).

VI Semester

CHEM/VI/CC/16 *Inorganic Chemistry-III-Theory*

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

Unit I

Organometallic compounds-I: Definition and classification of organometallic compounds. Preparations, properties and applications of alkyls and aryls of, Magnesium, Boron and Tin. A brief account of bonding in π -metal-alkenyl complexes.

Metal carbonyls: Preparation, structure and bonding of mononuclear and dinuclear metal carbonyls. π -acceptor property of CO and back bonding in metal carbonyls.

UNIT II

Bioinorganic Chemistry: Metalloporphyrins with reference to myoglobin and hemoglobin (structural aspects); Role of myoglobin and hemoglobin in biological systems. Metalloenzymes of Zinc (Carbonic anhydrase and carboxy peptidase) and their characteristics and functions. Role of alkali metals (Na^+ , K^+) and alkaline earth metals (Mg^{2+} , Ca^{2+}) in biological process.

Inorganic Polymers: Types of inorganic polymers; General properties of Inorganic polymers and comparison with organic polymers. Synthesis, structural aspects and applications of Silicones and polyphosphonitrilic chlorides.

UNIT III

Lanthanides: Electronic configurations, oxidation states, Lanthanide contraction; colour, Magnetic properties of M^{3+} ions, ability of complex formation, separation of Lanthanides by ion exchange method.

Actinides: Electronic configurations, oxidation states, colour and ability of complex formation. Comparison of Lanthanides and actinides.

UNIT IV

Magneto-Chemistry: Explanation of the terms - magnetic induction, permeability, intensity of magnetisation, magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism. Orbital magnetic moment; spin magnetic moment; Curie's law; Curie-Weiss law; Variation of magnetic susceptibility with temperature for paramagnetic, ferromagnetic and antiferromagnetic substances. Bohr Magneton. Explanation of the magnetic behaviour of simple inorganic coordination complexes.

UNIT V

A. Infrared Spectroscopy: Applications in inorganic compounds with reference to Metal-Halogen bonds (terminal and bridged), and metal-amine complexes.

B. Raman Spectroscopy: Introduction; Structure determination using Raman spectroscopy considering the following molecules or ions: CO_2 , N_2O , SO_2 , NO_3^- and ClO_3^- .

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers & Distributors.
2. Prakash, S. Tuli, G.D., Basu, S.K. & Madan, R.D. *Advanced Inorganic Chemistry*, Vol. I & II, S. Chand & Co.
3. R.L. Dutta, *Inorganic Chemistry*, Part-I Principle, The New Book Stall
4. Lee, J.D. *Concise Inorganic Chemistry*, ELBS.

- Huheey, J.E. *Inorganic Chemistry*, Prentice Hall.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*, New Age International Publisher.
 6. Nakamoto, K. *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, John Wiley & Sons, Inc.
-

CHEM/VI/CC/17
Inorganic Chemistry-III-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

(A) Complexometric Titrations: (Marks: 20+5)

- (i) Complexometric estimation of (i) Mg^{2+} (ii) Ca^{2+} using EDTA
- (ii) Estimation of temporary, permanent and total hardness of water sample(s).

(B) Argentometry: (Marks: 20+5)

Estimation of Cl^- (i) By Mohr's method (ii) By Vohlard's method.

(C) Oxidation- Reduction Titrimetry: (Marks: 20+5)

- (i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
- (ii) Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine/ anthranilic acid) and external (potassium ferricyanide) indicator.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended Texts:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS.
2. Vogel, A.I. *A text book of quantitative Inorganic Analysis*, ELBS.
3. Pandey, O.P., Bajpai, D.N., Giri, S. *Practical Chemistry*, S. Chand & Co.
4. Gurtu, J.N. & Kapoor, R. *Advanced Experimental Chemistry*, Vol. II, S. Chand & Co.

CHEM/VI/CC/18
Organic Chemistry-III-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

UNIT-I

Organic Photochemistry : Molecular energy and photochemical energy, excitation of molecules, Franck-Condon Principle, dissipation of energy and Jablonski-diagram, depicting various processes occurring in the excited state, singlet-triplet states, photosensitization, quenching and quantum yield. Qualitative description of fluorescence, phosphorescence, non-radiative processes (Internal conversion & inter system crossing).

Introduction to the photochemical reactions of carbonyl compounds, photoreduction, paterno-Buchi reaction, Norrish type-I and Norrish type-II cleavages.

UNIT-II

Pericyclic Reactions: Definition of Pericyclic reaction

(i) **Electrocyclic reactions**: stereochemistry of electrocyclic reaction, conrotatory – disrotatory ring closure and ring opening (with simple examples like 1,4 – disubstituted 1,3-butadiene, 1,6, - disubstituted, 1,3,5, hexatriene, 1,8, disubstituted, 1,3,5,7 – octatetraene). Woodward-Hofmann's rule for electrocyclic reactions. Frontier molecular orbital theory (correlation diagram not required)

(ii) **Cyclo addition reactions**: Definition of dienes and dienophiles, supra-supra, anta-antara, modes of cyclo additions ($\pi^4_{\sigma} + -\pi^2_{\sigma}$, $\pi^4_{\sigma} + \pi^2_{\alpha}$, $\pi^2_{\sigma} + \pi^2_{\sigma}$, $\pi^2_{\sigma} + \pi^2_{\alpha}$) by taking examples of simple dienes and dienophiles.

UNIT-III

Organometallic Compounds:

Organozinc Compounds – formation and chemical reactions.

Organolithium Compounds – formation and chemical reactions.

Organosulphur compounds: Nomenclature, structural features, method of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine

Synthetic applications of Grignard's reagent: Synthesis of alkanes, alcohols, acids, aldehydes, ketones and amines with mechanism.

UNIT-IV

Green Chemistry

Principles of Green Chemistry

Green Reactions with mechanism: Aldol Condensation, Baeyer – Villager Oxidation with Migratory Aptitude, Michael Addition, Diels-Alder Reaction, Wittig Reaction.

Microwave Assisted Organic Reactions in water: Mannich Reaction, Hofmann Elimination

Green Preparation (Sonication Reaction): Butyraldehyde, 2-Chloro-N-aryl anthranilic acid.

Organic Synthesis using Biocatalysts: Biochemical (Microbial) Oxidation and Reduction.

UNIT-V

(a) Mass-Spectrometry: Basic principle, types of ion produced in mass spectrometer, molecular ion-peak, base-peak and metastable ion, determination of molecular weight of organic compounds.

(b) Nuclear Magnetic Resonance Spectroscopy: Basic principle, chemical shifts, shielding and deshielding of protons, chemically and magnetically equivalent protons, NMR peak area and proton coupling, chemical shifts and coupling constants for ethyl bromide, ethanol, acetaldehyde, 1,1,2 – tribromo ethane, ethyl acetate, toluene and acetophenone.

Recommended Books

1. C.E. Wayne and RP Wayne, Photochemistry, Oxford University Press.
2. J.S. Jagdamba Singh, Photochemistry and Pericyclic reactions. New Age International Publishers.
3. S.C. Ameta, S, Meta and S. Sharma, Organic Photochemistry- An Introduction. Sadguru Publications.
4. R.R. Gupta, M. Kumar, V. Gupta, Heterocyclic Chemistry I & II, Springer.
5. Green Chemistry (Environmentally Benign Reactions), Ane Books India.
6. V.K. Ahluwalia, Green Solvents for Organic Synthesis, Narosa.
7. P.S. Kalsi, Spectroscopy of Organic Compounds, New Age International Publishers.

Additional References

1. Jag Mohan, Organic spectroscopy, principles and applications, Narosa Publishing House.
2. Flemming, Pericyclic Reactions, Oxford University Press.
3. P.R. Jenkins, Organometallic Reagents in synthesis, Oxford University Press.

CHEM/VI/CC/19
Organic Chemistry-III-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

A. UV/Vis Spectroscopy (Marks: 20+5)

1. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.
3. 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.
4. Determine the concentration of the given organic compound using UV-Vis spectrophotometer.

B. Synthesis of heterocyclic compounds and monitoring the progress of the reaction using Thin Layer chromatography: (Marks: 20+5)

1. Biginelli Condensation: Synthesis of 3, 4-dihydropyrimidin-2-ones using acid catalysts.
2. Hantzsch Ester synthesis: Synthesis of 1, 4-dihydropyridine.

C. Extraction of organic compounds: (Marks: 20+5)

1. Extraction of essential oils from plants (eucalyptus, Ageratina adenophora, etc) using cleverger apparatus.
2. Extraction and isolation of casein and lactose from milk.
3. Extraction of caffeine from tea leaves.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended 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 Organic Chemistry, 5th Ed., Pearson (2012).
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

CHEM/VI/CC/20
Physical Chemistry-III-Theory

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 3-1-0

UNIT I: Photochemistry

Difference between Thermal and Photochemical reactions; Grotthus-Draper law; Beer-Lambert's Law; Stark-Einstein law of photochemical equivalence and quantum yield, Photochemical reactions involving dissociation of HI, CH₃CHO; Photo-sensitized reaction involving photosensitizers; Quenching & Chemiluminescence.

UNIT II: Quantum Chemistry

Black body radiation; Planck's radiation law; Photoelectric effect; heat capacity of solids; Postulates of quantum mechanics; Schrodinger wave-equation and its applications to i) free particles ii) particle in a one dimensional (1D) box, quantization of energy levels, zero point energy, Schrodinger wave-equation for H-atom and its separation into three equations (without derivation).

UNIT III: Statistical Thermodynamics

Limitations of classical thermodynamics; Concept of distribution of energy; Thermodynamic probability; Boltzmann distribution law. Molecular partition function and its physical significance; Translational, Rotational, Vibrational and electronic partition functions; Relationship between thermodynamic functions and partition functions.

UNIT IV: Molecular spectroscopy: Interaction of Electromagnetic Radiation with molecules; Various types of Spectra, Born – Oppenheimer approximation.

(a) **Electronic Spectroscopy:** Electronic spectra of diatomic molecules; selection rules; fate of electronically excited states - radiative and non-radiative decay, fluorescence and phosphorescence.

(b) **Rotational spectroscopy:** Rotational energy levels of diatomic molecules (rigid rotor); relationship between the structure/nature of the molecule and selection rule; relative intensity of rotational spectral lines; determination of bond-length.

(c) **Vibrational Spectroscopy:** Vibrational energy levels of diatomic molecules (one dimensional harmonic oscillator); relationship between the structure/nature of the molecule selection-rules; evaluation of force constant from fundamental frequencies; anharmonicity and Morse potential. Dissociation energy, overtones, and hot bands.

(d) **Raman Spectroscopy:** Classical theory of Raman Effect; relationship between the structure/nature of the molecule Selection rules; Effect of nuclear spins, stokes and anti-stokes lines, Mutual exclusion rule.

UNIT V : Electrochemistry II:

Chemical 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. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes.

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Quantitative discussion of potentiometric titrations (acid-base, redox titrations).

Books Recommended:

1. Puri, Sharma, & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co, Jalandhar
2. Banwell, *Fundamentals of Molecular Spectroscopy*, Prentice hall of India.
3. P. A. Cox, *Introduction to Quantum Theory & Atomic Structure*, Oxford Univ. Press (OUP).
4. V. K. Jain, *Introduction to Atomic and Molecular Spectroscopy*, Narosa Publishing House.

Additional References:

1. D. A, Macquarie & J. D. Simon, *Physical Chemistry a Molecular Approach*, Viva Books Pvt. Ltd.
2. R. K. Prasad, *Quantum Chemistry*, New Age International Publishers, N. Delhi.
3. John M. Brown, *Molecular Spectroscopy*, Oxford Univ. Press (OUP).

CHEM/VI/CC/21
Physical Chemistry-III-Practical

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 0-0-2

Marks (60+15)

1. Determination of the partition coefficient of Iodine between CCl_4 and water.
2. Determination of the partition coefficient of Iodine between Kerosene and water.
3. Determination of the partition coefficient of benzoic acid between benzene and water.
4. Verification of Beer-Lambert's law using copper sulphate or $\text{K}_2\text{Cr}_2\text{O}_7$ solution, Colorimetrically or Spectrometrically and determination of the concentration of the above solution.
5. To study the adsorption of oxalic acid on activated charcoal and to verify Freundlich's adsorption isotherm.
6. Preparation of colloidal sols of Arsenious sulphide, $\text{Fe}(\text{OH})_3$, and Prussian blue sols.

Books Recommended

1. B. Viswanathan and P.S. Raghavan, *Practical Physical Chemistry*, Viva Books Private Limited, New Delhi
2. S. Chawla, *Essentials of Experimental Engineering Chemistry*, Dhanpat Rai & Co., New Delhi
3. J. B. Yadav, *Advance Practical Physical Chemistry*, Geol Publishing House, Meerut.

NOTE: Experiments may be added/deleted subject to the availability of Chemicals/apparatus.

CHEM/VI/CC/22 (A)*
Material Chemistry (Option A)

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 4-2-0

Unit I

Historical Perspectives, Materials and their classification, Consideration in the design of new materials, Solid state-amorphous vs crystalline solids, types of bonding-ionic solids, metallic solids, molecular solids and covalent network solids; crystalline state-unit cell, crystal lattice, crystal imperfections, phase transformation diagram; amorphous state-sol-gel processing, glasses, cementations materials; semiconducting materials- properties and types; silicon-base applications-silicon wafer productions.

Unit II

Phase Equilibria

Introduction, Phase, Components, Degree of freedom, Derivation of the phase rule, one component systems, The water system, The carbon dioxide system, two component systems, simple eutectic system, thermal analysis-cooling curves, lead-silver system, freezing mixtures, formation of compounds with congruent melting points, ferric chloride-water system, calculation of eutectic point and eutectic composition, three component solid-liquid systems-acetic acid-chloroform-water system.

Unit III

Macromolecules

Introduction, classification of polymers, isotactic polymers, atactic polymers, syndiotactic polymers, stereoregular polymers, graft polymers, polymerization reactions, molar masses of polymers, determination of molar masses of macromolecules, Donald membrane equilibrium, Einstein equation, conformations and configurations of macromolecules in solution, kinetics of polymerization, Flory-Huggins theory.

Unit IV

Hybrid Materials

Introduction Natural, Origin, department of hybrid materials, combining inorganic and organic species in one material, interface-determine materials, role of the interaction mechanism, Hybrid organic/inorganic particles
Introduction, methods for creating particles, polymer particles, oil-in-water suspension polymerization, vesicles assemblies and dendrimers, block copolymer assemblies, inorganic particles, metal oxide particle, metallic particles, semiconductor nanoparticles.

Unit V

Nanomaterials

Introduction, nanomaterial and nanocomposites, elementary consequences of small particle size, thermal phenomena, diffusion law, surface of nanoparticles-general consideration, surface energy, some technical consequences of surface energy, , phase transformations of nanoparticles-thermodynamics, heat capacity, , phase transformation of nanoparticles, phase transformation and coagulation, magnetic materials, Applications of nanomaterials.

Books Recommended

1. B. D. Fahlman, Material Chemistry, Springer Publication(2008). [ISBN-978-1-4020-6119-6]
2. D. Vollath, Nanomaterials, Wiley-VCH, Weinheim (2008) [ISBN-3-527-31531-4]
3. G. Kickelbick, Wiley-VCH, Weinheim (2006). [3-527-31299-4].

CHEM/VI/CC/22 (B)*
Natural Products (Option B)

Marks [Scaled]: 100 (Internal Exam: **25** + End Semester Exam: **75**) Credits: 4-2-0

Unit I

Introduction: (a) Terpenes: Classification, Biosynthesis of terpenes, Some representative: Monoterpenes, Sesquiterpenes, Diterpenes, Sesterterpenes, Triterpenes, Tetraterpenoids
(b) Alkaloids: Isolation, Detection, The Hoffmann degradation.

Unit II

A survey of the methods used for determination of structures: Spectroscopic Methods: Ultraviolet – Visible spectroscopy, Infrared Spectroscopy, NMR Spectroscopy, Mass Spectroscopy.

Unit III

Stereochemistry:

Absolute stereochemistry of morphine and benzyl isoquinoline alkaloids, Conformation of naturally occurring germacranolides, Stereochemistry of rotenoids, Abietic acid, Menthol and Vinblastine.

Unit IV

Reactions & Rearrangements:

Rearrangement reaction of Morphine, The Wesley – Moser rearrangement, Molecular Yoga: Reactions of papaverine, The Nametkin rearrangement

Biological significance of Secondary Metabolites: Insect Pheromones, Plant - Insect interactions, Defensive secretion of Insects.

Unit V

Synthesis:

Synthesis of a semiochemical, Synthesis of a chiral marine natural product, A stereoselective Synthesis of reserpine, Synthesis of a paraconic acid.

Biosynthesis:

Biosynthesis of some benzylisoquinoline alkaloids, Biosynthesis and transformation of isoflavones, Reticuline to morphine.

Books Recommended

1. Chemistry of Natural Products, S.V. Bhat, B.A. Ngasampagi and M. Sivakumar, Narosa Publishing House (2005)
2. Chemistry of Natural Products, N.R. Krishnaswamy, University Press, 2nd Edition(2009)