

6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
7. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985).
8. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).

Semester III

Course Code: CHEM-MAT-3
Course Title: Inorganic-1B & Physical-1B

Inorganic -1B

- 1. Redox Reactions and precipitation reactions : (15L)**
Qualitative idea about complimentary, noncomplimentary, disproportionation and comproportionation reactions, standard redox potentials with sign conventions, Electrochemical series and its application to explore the feasibility of reactions and equilibrium constants, Nernst equation; effect of pH, complexation and precipitation on redox potentials, formal potential; Basis of redox titration and redox indicators, Redox potential diagrams (Latimer and Frost) of common elements and their applications.
Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulphides, carbonates, sulphates and halides.
- 2. Acid-Base Concepts and Solvents : (15L)**
Recapitulation of Arrhenius concept, Bronsted-Lowry concept, Solvent system concept (in H₂O, liq. NH₃, liq. SO₂ and liq. HF), Lux-Flood concept, Lewis concept, Solvent levelling and differentiating effects, Relative strength of different acids and bases, Pauling's rules, Hammett acidity function and super acids, HSAB principle and its applications, Acid-base equilibria in aqueous solution, pH, Buffer, Acid-base neutralization curves and choice of indicators.

Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970.
3. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
4. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
5. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
6. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.

7. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
8. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
9. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).
10. Winter, M. J., The Orbitron, [http:// winter.group.shef.ac.uk/orbitron/](http://winter.group.shef.ac.uk/orbitron/) (2002). An illustrated gallery of atomic and molecular orbitals.
11. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).
12. Das, A. K., Fundamental Concepts of Inorganic Chemistry, Vol-1-6, Third Edition, CBS Publishers and Distributors.

Physical-1B

1. Chemical Thermodynamics - II

(12 L)

Second Law: Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine and refrigerator; Kelvin –Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of $\int dQ/T$ and Clausius inequality; Entropy change involved in various processes and transformations; Entropy and unavailable work; Free energy functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium.

Thermodynamic relations: Maxwell's relations; Gibbs-Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas; General heat capacity relations.

2. Chemical kinetics

(18 L)

Rate law, order and molecularity: Introduction of rate law, Extent of reaction; rate constants, order; Forms of rates of First, second and nth order reactions; Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate); Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions, kinetic and thermodynamic control of products.

Role of Temperature and theories of reaction rate: Temperature dependence of rate constant; Arrhenius equation, energy of activation; Rate-determining step and steady-state approximation – explanation with suitable examples; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment).

Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turnover number.

Reference Books

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press.
2. Castellan, G. W. Physical Chemistry, Narosa.
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press.
4. Engel, T. & Reid, P. Physical Chemistry, Pearson.
5. Levine, I. N. Physical Chemistry, Tata McGraw-Hill.
6. Maron, S. & Prutton Physical Chemistry.
7. Ball, D. W. Physical Chemistry, Thomson Press.
8. Mortimer, R. G. Physical Chemistry, Elsevier.
9. Laidler, K. J. Chemical Kinetics, Pearson.
10. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry.
11. Rakshit, P.C., Physical Chemistry Sarat Book House.
12. Zemansky, M. W. & Dittman, R.H. Heat and Thermodynamics, Tata-McGraw-Hill.
13. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas.
14. Clauze & Rosenberg, Chemical Thermodynamics

Course Code: CHEM-MAP-3

Course Title: Inorganic-1B & Physical-1B

Inorganic-1B

- i. Estimation of Fe(III) using $K_2Cr_2O_7$ solution
- ii. Estimation of Ca^{2+} using $KMnO_4$ solution
- iii. Estimation of Cu^{2+} iodometrically
- iv. Estimation of Cr^{3+} using $K_2Cr_2O_7$ solution

Reference Book

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

Physical-1B

- i. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate.
- ii. Study of kinetics of decomposition of H_2O_2 .

Reference Books

1. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson.
3. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
4. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
5. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
6. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
7. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.

Course Code: CHEM-MIT-1B
Course Title: Physical-1 & Inorganic-2

Physical-1

1. Kinetic Theory of Gases and Real gases (9L)

- a. Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion
- b. Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases
- c. Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states
- d. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only)

2. Liquids (4L)

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

3. Solids (4L)

Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl treatment only); Defects in crystals; Glasses and liquid crystals.

4. Chemical Kinetics

(5L)

- a. Introduction of qualitative rate law, order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions
- b. Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)

Inorganic-2

1. Chemical Bonding and Molecular Structure

(12L)

- a. Ionic Bonding: General characteristics of ionic bonding. lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment.
- b. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples from s and p block elements of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.
- c. 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).

2. Coordination Chemistry

(11L)

- a. Werner's coordination theory, 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.
- b. Drawbacks of VBT. IUPAC system of nomenclature.
- c. Crystal Field Theory (CFT): Postulates of CFT, splitting of d-orbitals in octahedral and tetrahedral fields, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Factors affecting the magnitude of Δ . Spectrochemical series. Comparison of CFSE for O_h and T_d complexes.

Reference Books

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. 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).
- Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry Kalyani Publishers.
- Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. Ltd.
- Palit, S. R., Elementary Physical Chemistry Book Syndicate Pvt. Ltd.
- Mandal, A. K. Degree Physical and General Chemistry Sarat Book House.
- Pahari, S., Physical Chemistry New Central Book Agency.
- Pahari, S., Pahari, D., Problems in Physical Chemistry New Central Book Agency.
- 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.

Course Code: CHEM-MIP-1B

Course Title: Physical-1 & Inorganic-2

Physical-1

- Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer
- Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer
- Study of the kinetics of acid hydrolysis of methyl acetate using hydrochloric acid.

Inorganic-2

Qualitative semi-micro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions.

Acid Radicals: Cl^- , Br^- , I^- , NO_2^- , NO_3^- , S^{2-} , SO_4^{2-} , BO_3^{3-} , H_3BO_3 .

Basic Radicals: K^+ , Ca^{2+} , Sr^{2+} , Ba^{2+} , Cr^{3+} , Mn^{2+} , Fe^{3+} , Ni^{2+} , Cu^{2+} , NH_4^+ .

Reference Books

- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003.
- Palit, S.R., Practical Physical Chemistry Science Book Agency.
- Mukherjee, N.G., Selected Experiments in Physical Chemistry J. N. Ghose & Sons.
- Dutta, S.K., Physical Chemistry Experiments Bharati Book Stall.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.

6. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Course Code: CHEM-MDC-3

Course Title: Basic Idea of Clinical Biochemistry (Multidisciplinary Course)

1. Biomolecules

(30L)

Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.

Proteins: Classification, biological importance; Primary and secondary and tertiary structures of proteins: α -helix and β -pleated sheets, denaturation of proteins, preliminary idea of enzymes, application of Biocatalyst in Chemical Industry.

Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Properties and functions of steroid hormones.

2. Biochemistry of disease: A diagnostic approach by blood/ urine analysis

(15L)

Blood: Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

Urine: Sampling and preservation, composition and estimation of constituents of normal and pathological urine.

Reference Books

1. Cooper, T.G. Tool of Biochemistry. Wiley-Blackwell (1977).
2. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: Practical Clinical Biochemistry, Heinemann, London (1980).
4. Devlin, T.M., Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons, 2010.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
6. Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H. Freeman, 2013.
8. O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods, D. Van Nostrand & Co., 1961.

CHEM-SEC-3

Course Title: Basic Analytical Chemistry (Skill Enhancement course)

1. Introduction

(3L)

Strategies of Analytical Chemistry and its interdisciplinary applicability. Protocol of sampling. Variability and validity of analytical measurements. Presentation of experimental data and results from the point of view of significant figures.

2. Complexometry

(5L)

Complexometric titrations, Chelation, Chelating agents, use of indicators. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

3. Soil Analysis

(3L)

Composition, pH of soil samples, estimation of calcium and magnesium content.

4. Analysis of water

(5L)

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

Determination of pH, acidity and alkalinity of a water sample.

Determination of Biological Oxygen Demand (BOD).

5. Analysis of food products

(5L)

Nutritional value of foods, idea about food processing and food preservations and adulteration.

Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

Analysis of preservatives and colouring matter.

6. Chromatography

(5L)

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}).

7. Ion-exchange

(4L)

Column, ion-exchange chromatography etc., Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

8. Analysis of cosmetics

(5L)

Major and minor constituents and their function

Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration

9. Suggested Applications (Any one) (4L)

To study the use of phenolphthalein in trap cases.

To analyse arson accelerants.

To carry out analysis of gasoline.

10. Suggested Instrumental demonstrations (6L)

Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.

Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks

Reference Books

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6th Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994).
4. Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016.
5. Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004.
6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992.
7. Freifelder, D.M. Physical Biochemistry 2nd Ed., W.H. Freeman & Co., N.Y. USA (1982).
8. Cooper, T.G. The Tools of Biochemistry, John Wiley & Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996.
10. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
11. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).
12. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

Semester IV

Course Code: CHEM-MAT-4

Course title: Organic-2

1. Stereochemistry-II: (14L)

Chirality arising out of stereoaxis: Stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, spiro compounds, alkylidenecycloalkanes and

biphenyls; related configurational descriptors (R_a/S_a and P/M); atropisomerism; racemisation of chiral biphenyls; buttressing effect.

Concept of prostereoisomerism: Prostereogenic centre; concept of proⁿ-chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-r and pro-s descriptors of ligands on propseudoasymmetric centre.

Conformation: Conformational nomenclature: eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; P/M descriptors; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, n-butane, 2-methylbutane and 2,3-dimethylbutane; haloalkane, 1,2-dihaloalkanes and 1,2-diols (up to four carbons); 1,2-halohydrin; conformation of conjugated systems (s-cis and s-trans).

2. General Treatment of Reaction Mechanism II : (18L)

Reaction thermodynamics: Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions.

Concept of organic acids and bases: Effect of structure, substituent and solvent on acidity and basicity; proton sponge; gas-phase acidity and basicity; comparison between nucleophilicity and basicity; HSAB principle; application of thermodynamic principles in acid-base equilibria.

Tautomerism: Prototropy (keto-enol, nitro - aci-nitro, nitroso-oximino, diazo-amino and enamine-imine systems); valence tautomerism and ring-chain tautomerism; composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism; application of thermodynamic principles in tautomeric equilibria.

Reaction kinetics: Rate constant and free energy of activation; concept of order and molecularity; free energy profiles for one-step, two-step and three-step reactions; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and secondary kinetic isotopic effect (k_H/k_D); principle of microscopic reversibility; Hammond's postulate.

3. Substitution and Elimination Reactions: (28L)

Free-radical substitution reaction: Halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.

Nucleophilic substitution reactions: Substitution at sp^3 centre: mechanisms (with evidence), relative rates & stereochemical features: S_N1 , S_N2 , S_N2' , S_N1' (allylic rearrangement) and S_Ni ; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP; role of crown ethers and phase transfer catalysts; [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides]. Concept of aliphatic electrophilic substitution reactions (S_E1 , S_E2 , S_Ei).

Elimination reactions: $E1$, $E2$, $E1cb$ and E_i (pyrolytic syn eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/ Hofmann) and stereoselectivity; comparison between substitution and elimination; importance of Bredt's rule relating to the formation of $C=C$.

Reference Books:

1. Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012.
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
4. Carey, F. A. & Giuliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.
6. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
7. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
8. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. Organic Chemistry (Volume 1) Pearson Education.
10. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc.
11. Eames, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003.
12. Robinson, M. J. T. Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.
13. Maskill, H. Mechanisms of Organic Reactions, Oxford Chemistry Primer, Oxford University Press.
14. March, J. Advanced Organic Chemistry, Fourth edition, Wiley.

Course Code: CHEM-MAP-4

Course title: Organic-2

Organic Preparations:

A. The following reactions are to be performed, noting the yield of the crude product:

1. Nitration of aromatic compounds
2. Condensation reactions
3. Hydrolysis of amides/imides/esters
4. Acetylation of phenols/aromatic amines
5. Benzoylation of phenols/aromatic amines
6. Side chain oxidation of aromatic compounds
7. Diazo coupling reactions of aromatic amines
8. Bromination of anilides using green approach (Bromate-Bromide method)
9. Selective reduction of m-dinitrobenzene to m-nitroaniline

Students must also calculate percentage yield, based upon isolated yield (crude) and theoretical yield.

B. Purification of the crude product is to be made by crystallisation from water/alcohol, crystallization after charcoal treatment, or sublimation, whichever is applicable.

C. Melting point of the purified product is to be noted.

Reference Books:

1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors.
2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).
5. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
6. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

Course Code: CHEM-MAT-5

Course title: Physical-2

1. Transport processes

(20 L)

Viscosity: General features of fluid flow (streamline flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation; Principle of determination of viscosity coefficient of liquids by falling sphere method; Temperature variation of viscosity of liquids and comparison with that of gases.

Conductance and transport number: Ion conductance; Conductance and measurement of conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of

independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Debye–Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, relaxation effect and electrophoretic effect; Ostwald's dilution law; Ionic mobility; Few applications of conductance measurement; Conductometric titrations. Transport number, Principles of Hittorf's and Moving-boundary methods.

2. Applications of Thermodynamics –I

(20 L)

Partial properties and chemical potential: Chemical potential and activity, partial molar quantities, relation between chemical potential and Gibb's free energy and other thermodynamic state functions; variation of chemical potential (μ) with temperature and pressure; Gibbs-Duhem equation; fugacity and fugacity coefficient; Variation of thermodynamic functions for systems with variable composition; Equations of states for these systems, Change in G, S H and V during mixing for binary solutions.

Chemical Equilibrium: Thermodynamic conditions for equilibrium, degree of advancement; Van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of K_p , K_c and K_x ; Van't Hoff's reaction isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant on addition of inert gas; Le Chatelier's principle. Nernst's distribution law; Application-(finding out K_{eq} using Nernst distribution law for $KI + I_2 = KI_3$ and dimerization of benzoic acid).

Chemical potential and other properties of ideal substances-pure and mixtures:

Pure ideal gas: Its chemical potential and other thermodynamic functions and their changes during mixing; Chemical potential of an ideal gas in an ideal gas mixture; Concept of standard states and choice of standard states of ideal gases.

Condensed Phase: Chemical potential of pure solid and pure liquids, Ideal solution–Definition, Raoult's law; Mixing properties of ideal solutions, chemical potential of a component in an ideal solution; Choice of standard states of solids and liquids.

3. Foundations of Quantum Mechanics

20 L

Advent of Quantum Mechanics: Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (without proof).

Wave function: Schrodinger time-independent equation; nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function.

Concept of Operators: Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators; Commutation of operators, commutator and uncertainty relation; Expectation value; Hermitian operator; Postulates of Quantum Mechanics.

Particle in a box: Setting up of Schrodinger equation for one-dimensional box and its solution; Comparison with free particle eigenfunctions and eigenvalues. Wave functions of particle in a box (normalisation, orthogonality, probability distribution); Expectation values of x , x^2 , p_x and p_x^2 and their significance in relation to the uncertainty principle; Extension of the problem to two and three dimensions and the concept of degenerate energy levels.

Reference Books

1. Atkins, P. W. & Paula, J. de Atkins', Physical Chemistry, Oxford University Press.
2. Castellan, G. W. Physical Chemistry, Narosa.
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press.
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill.
5. Rakshit, P.C., Physical Chemistry, Sarat Book House.
6. Moore, W. J. Physical Chemistry, Orient Longman.
7. Mortimer, R. G. Physical Chemistry, Elsevier.
8. Denbigh, K. The Principles of Chemical Equilibrium Cambridge University Press.
9. Engel, T. & Reid, P. Physical Chemistry, Pearson.
10. Levine, I. N. Quantum Chemistry, PHI.
11. Atkins, P. W. Molecular Quantum Mechanics, Oxford.
12. emansky, M. W. & Dittman, R.H. Heat and Thermodynamics, Tata-McGraw-Hill.
13. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas.
14. Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics:Basic Concepts and Methods Wiley.
15. Glasstone, S. An Introduction to Electrochemistry, East-West Press.

Course Code: CHEM-MAP-5

Course title: Physical-2

- i. Determination of viscosity of unknown liquids (aqueous solution of glycerol and sugar) with respect to water.
- ii. Determination of partition coefficient for the distribution of I_2 between water and CCl_4 .
- iii. Determination of K_{eq} for $KI + I_2 = KI_3$, using partition coefficient between water and CCl_4 .
- iv. Conductometric titration of an acid (strong, weak, monobasic, dibasic) against strong base.
- v. Study of saponification reaction conductometrically.
- vi. Verification of Ostwald's dilution law and determination of K_a of weak acid.

Reference Books

1. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)

2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson.
3. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
4. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
5. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
6. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
7. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co.Ltd.

Course Code: CHEM-MIT-2B

Course Title: Physical-1 & Inorganic -2

Physical-1

1. Kinetic Theory of Gases and Real gases (9L)

- a. Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion
- b. Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases
- c. Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states
- d. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only)

2. Liquids (4L)

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

3. Solids (4L)

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

4. Chemical Kinetics

(5L)

- a. Introduction of qualitative rate law, order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions
- b. Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)

Inorganic-2

1. Chemical Bonding and Molecular Structure

(12L)

- a. Ionic Bonding: General characteristics of ionic bonding. lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment.
- b. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples from s and p block elements of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.
- c. 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).

2. Coordination Chemistry

(11L)

- a. Werner's coordination theory, 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.
- b. Drawbacks of VBT. IUPAC system of nomenclature.
- c. Crystal Field Theory (CFT): Postulates of CFT, splitting of d-orbitals in octahedral and tetrahedral fields, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Factors affecting the magnitude of Δ . Spectrochemical series. Comparison of CFSE for O_h and T_d complexes.

Reference Books

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. 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).
- Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry Kalyani Publishers.
- Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. Ltd.
- Palit, S. R., Elementary Physical Chemistry Book Syndicate Pvt. Ltd.
- Mandal, A. K. Degree Physical and General Chemistry Sarat Book House.
- Pahari, S., Physical Chemistry New Central Book Agency.
- Pahari, S., Pahari, D., Problems in Physical Chemistry New Central Book Agency.
- 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.

Course Code: CHEM-MIP-2B

Course Title: Physical-1 & Inorganic-2

Physical-1

- Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer
- Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer
- Study of the kinetics of acid hydrolysis of methyl acetate using hydrochloric acid.

Inorganic-2

Qualitative semi-micro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions.

Acid Radicals: Cl^- , Br^- , I^- , NO_2^- , NO_3^- , S^{2-} , SO_4^{2-} , BO_3^{3-} , H_3BO_3 .

Basic Radicals: K^+ , Ca^{2+} , Sr^{2+} , Ba^{2+} , Cr^{3+} , Mn^{2+} , Fe^{3+} , Ni^{2+} , Cu^{2+} , NH_4^+ .

Reference Books

- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003.
- Palit, S.R., Practical Physical Chemistry Science Book Agency.
- Mukherjee, N.G., Selected Experiments in Physical Chemistry J. N. Ghose & Sons.
- Dutta, S.K., Physical Chemistry Experiments Bharati Book Stall.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.

6. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).