JSS Mahavidyapeetha

JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING

JSS TI Campus, Mysuru, Karnataka 570 006

PROGRAMME

M.Sc., CHEMISTRY

2 YEARS / 4 SEMESTERS

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SYLLABUS - 2017-18

I SEMESTER

ANALYTICAL CHEMISTRY-I

UNIT I

Analytical Chemistry – Introduction of analytical chemistry, Meaning and analytical prospective, scope and function: Analytical problems and their solutions, trends in analytical methods and procedures.
Analysis, determination and measurement. Techniques, methods, procedures and protocols. Classifying analytical techniques. selecting an analytical method - accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Scale of operation, equipment, time and cost. Making the final choice
Errors and treatment of analytical data: Limitations of analytical methods – Error: determinate and indeterminate errors, minimization of errors. Accuracy and precision, distribution of random errors, the normal error curve. Statistical treatment of finite samples - measures of central tendency and variability: mean, median, range, standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance - comparison of two means and two standard deviations. Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation - Q-test. Propagation of errors: determinate errors and indeterminate errors. **13 Hours**

UNIT II

Standardization: Comparison with standards - direct comparison and titrations. External standard calibration - the least squares methods, regression equation, regression coefficient. Internal standard methods and standard-addition methods. Figures of merit of analytical methods - sensitivity and detection limit, linear dynamic range.
Titrimetric analysis: An overview of titrimetry. Principles of titrimetric analysis. Titration curves.
Titrations based on acid-base reactions - titration curves for strong acid and strong base, weak acid and strong base and weak base and strong acid titrations. Selecting and evaluating the end point. Finding the end point by visual indicators, monitoring *p*H and temperature. Quantitative applications – selecting and standardizing a titrant. Organic analysis - functional groups like carboxylic acid, sulphonic acid, amine, ester, hydroxyl, carbonyl. **13 Hours**

UNIT III

Acid-base titrations in non-aqueous media: Role of solvent in acid-base titrations, solvent systems, differentiating ability of a solvent, some selected solvents, titrants and standards, titration curves, effect of water, determining the equivalence point, typical applications - determination of carboxylic acids, phenols and amines.
Redox titrations: Balancing redox equations, calculation of the equilibrium constant of redox reactions, calculating titration curves, detection of end point, visual indicators and potentiometric end point detection. Quantitative applications - adjusting the analyte's oxidation state, selecting and standardizing a titrant. Inorganic analysis - chlorine residuals, dissolved oxygen in water, water in non-aqueous solvents.

Organic analysis - chemical oxygen demand (COD) in natural and waste waters, titrations of mercaptans and ascorbic acid with I_3^- and titration of organic compounds using periodate. **13 Hours**

UNIT IV

Complexometric titrations: Complex formation reactions, stability of complexes, stepwise formation constants, chelating agents, EDTA - acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves, effect of other complexing agents, factors affecting the shape of titration curves - completeness of reaction, indicators for EDTA titrations - theory of common indicators, titration methods employing EDTA - direct, back and displacement titrations, indirect determinations, titration of mixtures.

Precipitation titrations: Titration curves, feasibility of precipitation titrations, factors affecting shape - titrant and analyte concentration, completeness of the reaction, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the Fajan's methods, typical applications.

13 Hours

References

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001, John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Principles and Practice of Analytical Chemistry, F.W. Fifield and Kealey, 3rd edition, 2000, Blackwell Sci., Ltd. Malden, USA.
7. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.

Inorganic Chemistry

INORGANIC CHEMISTRY-I

UNIT I

Ionic bond: properties of ionic substances, coordination number of an ion, structures of crystal lattices- NaCl, CsCl, ZnS and rutile. Lattice energy- Born Lande equation, Born-Haber cycle, Uses of Born-Haber type of calculations. Ionic radii, factors affecting ionic radii, radius ratio rule, covalent character in ionic bonds, hydration energy and solubility of ionic solids.

Structures and energetics of inorganic molecules: Introduction, Energetics of hybridization. VSEPR model for explaining structure of AB, AB_2E, AB_3E, AB_2E_2, ABE_3, AB_2E_3, AB_4E_2, AB_5E and AB_6 molecules. M.O. treatment of homonuclear and heteronuclear diatomic molecules. M.O. treatment involving delocalized π-bonding (CO_3^{2-} , NO_3^- , NO_2^-, CO_2 and N_3^-), M.O. correlation diagrams (Walsh) for triatomic molecules.

[13 hours]

UNIT II

Molecular symmetry and group theory: Symmetry elements and symmetry operations. Concept of a group, definition of a point group. Classification of molecules into point groups. Subgroups. Schoenflies and Hermann-Maugin symbols for point groups. Multiplication tables (C_n, C_{2V} and C_{3V}). Matrix notation for the symmetry elements. Classess and similarity transformation.

Representation of groups: The Great Orthogonality theorem and its consequences. Character tables (C_s, C_i, C_2, C_{2v}, C_{2h} and C_{3v}).

Applications of group theory: Group theory and hybrid orbital. Group theory to Crystal field theory and Molecular orbital theory (octahedral and tetrahedral complexes). Determining the symmetry groups of normal modes (both linear and non-linear molecules).

[13 hours]

UNIT-III

Preparation of coordination compounds: Introduction, Preparative methods - simple addition reactions, substitution reactions, oxidation-reduction reactions, thermal dissociation reactions, reactions of coordinated ligands, the trans-effect, other methods.

Geometries of metal complexes: coordination numbers 2-10.

Stability of coordination compounds: Introduction, trends in stepwise stability constants, factors influencing the stability of metal complexes with reference to the nature of metal ion and ligands, the Irving-William series, chelate effect.

Determination of stability constants: Theoretical aspects of determination of stability constants of metal complexes by spectrophotometric, *p*H metric and polarographic methods.

UNIT IV

Reaction Mechanisms in Transition Metal Complexes: Energy profile of a reaction, inert and labile complexes, kinetics of octahedral substitution and mechanistic aspects. Acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism and evidences in its favour. Anation reactions, reactions without M-L bond cleavage.

Substitution reactions in square planar complexes, trans effect, mechanisms of substitution.

Electron transfer reactions- inner sphere and outer sphere reactions, the Marcus theory, complimentary and non-complimentary reactions.

Thermodynamic and related aspects of ligand fields: Hydration, ligation and lattice energies.

References:

1. Symmetry and spectroscopy of molecules, 2nd Ed. Veera Reddy, New Age International Publication (2009).
2. Group Theory and its Chemical Applications, P.K. Bhattacharya, Himalaya Publishing House (1986).
3. Chemical Applications of Group Theory, 3rd Ed., F.A. Cotton,Wiley, New York (1990).
4. Inorganic Chemistry, 3rd edition. James E. Huheey, Harper and Row Publishers (1983).
5. Inorganic Chemistry, 3rd edition. G.L. Miessler and D.A. Tarr, Pearson Education (2004).
6. Inorganic Chemistry, 4th edition. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Oxford University Press (2004).
7. Inorganic Chemistry, 2nd edition. C.E. Housecroft and A.G. Sharpe, Pearson Education Ltd. (2005).
8. Basic Organometallic Chemistry - B.D. Gupta and A.J. Elias, Universities Press (2010).
9. Physical Inorganic Chemistry - A Coordination Chemistry Approach- S.F.A. Kettle, Spektrum, Oxford, (1996).

STEREOCHEMISTRY AND REACTION MECHANISM

UNIT – I

Stereoisomerism: Projection formulae [Fly wedge, Fischer, Newman and Saw horse], enantiomers, diasteroisomers, configurational notations of simple molecules, *DL* and *RS* configurational notations.

Stereoselectivity: Stereoselective reactions, diasteroselective reactions, stereospecific reactions, regioselective and regiospecific reactions, enantioselective and enantiospecific reactions.

Optical isomerism: Conditions for optical isomerism, Elements of symmetry – plane of symmetry, centre of symmetry, alternating axis of symmetry (rotation-reflection symmetry); optical isomerism due to chiral centers and molecular dissymmetry, allenes and biphenyls, criteria for optical purity.

Geometrical isomerism: Due to C=C, C=N and N=N bonds, E, Z conventions, determination of configuration by physical and chemical methods.

Molecular representations: Wedge, Fischer, Newman and Saw-horse formulae, their description and interconversions.

Molecular Symmetry & Chirality: Symmetry operations and symmetry elements (Cn&Sn). Criteria for Chirality. Desymmetrization. Axial, planar and helical chirality: Axially chiral allenes,spiranes,alkylidene cycloalkanes, chiral biaryls, atropisomerism, planar chiral ansa compounds and trans- cyclooctene, helically chiral compounds and their configurational nomenclature Relative and absolute configuration: Determination of configuration by chemical correlation methods. Racemisation and resolution techniques: Racemisation, resolutions by direct crystallization, diastereoisomer salt formation chiral chromatography and asymmetric transformation. Determination of configuration in E, Z-isomers: Spectral and Chemical methods of configuration determination of E, Z isomers. Determination of configuration in aldoximes and Ketoximes

13Hrs

UNIT – II

Reaction mechanism

Structure and reactivity: Brief discussion on effects of hydrogen bonding, resonance, inductive and hyperconjugation on strengths of acids and bases.

Methods of determining organic reaction mechanism: Thermodynamic and kinetic requirements for reactions, kinetic and thermodynamic control. Hammonds postulates and Curtin-Hammett principle.Identification of products. Formation, structure, stability, detection and reactions of carbocations (classical and non-classical), carbanions, free radicals, carbenes, nitrenes, nitrile oxides, nitrile imines, nitrile ylides and arynes. Determination of reaction intermediates, isotope labeling and effects of cross over experiments. Kinetic and stereochemical evidence, solvent effect. Linear free energy relationship-Hammet equation and Taft treatment.

13Hrs

UNIT – III

Basics of organic reactions: Meaning and importance of reaction mechanism, classification and examples for each class.

Aliphatic substitution reactions:

Nucleophilic substitution reactions: Kinetics, mechanism and stereochemical factors affecting the rate of reactions, Neighbouring group participation.

Electrophilic substitution reactions: S_E^1 and S_E^2reactions

Aromatic substitution reactions:

Nucleophilic substitution reactions: S_N^1, S_N^2 and benzyne mechanism, Bucherer reaction.

Electrophilic substitution reactions: Mechanism of Friedel-Crafts alkylation and acylation, Mannich reaction, chloromethylation, Vilsmeier-Haack reaction. **13Hrs**

UNIT-IV

REACTION MECHANISM-I

Electrophilic addition to carbon carbon double bond: Stereoselective addition to carbon carbon double bond; *anti* addition- Bromination and epoxidation followed by ring opening. *Syn* addition of OsO4 and KMnO4.

Elimination reactions Elimination reactions E2, E1, E1CB mechanisms. Orientation and stereoselectivity in E2 eliminations. Pyrolytic*syn*elimination and α-elimination, elimination Vs substitution.

Mechanism of hydrolysis of carboxylic acid derivatives: Hydrolysis of esters, amides and acid chlorides.

Elimination reactions: Mechanism and stereochemistry of eliminations - E_1, E_2, E_1cB. *cis* elimination, Hofmann and Saytzeff eliminations, competition between elimination and substitution, decarboxylation reactions. Chugaev reaction.

Determination of reaction mechanism: Determination of reaction mechanism: Energy profiles of addition and elimination reactions, transition states, product isolation and structure of intermediates, use of isotopes, chemical trapping and crossover experiments. Use of IR and NMR in the investigation of reaction mechanism.

13Hrs

References:

1. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mc Graw Hill, New York, 1987.
2. Organic Chemistry by Morrison & Boyd.
3. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.
4. E.L. Eliel and S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley and Sons, New York. 1994.
5. Introduction to Stereochemistry by K. Mislow.
6. Basic Principles of Organic Chemistry by Roberts & Caserio
7. N.S. Issacs, Reactive Intermediates in Organic Chemistry, John Wiley and Sons, New York.1974.
8. R.K. Bansal, Organic Reaction Mechanism, Wiley Eastern Limited, New Delhi, 1993.
9. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
10. E.S. Gould, Mechanism and Structure in Organic Chemistry, Halt, Rinhart & Winston, New York, 964.
11. A Guide Book to Mechanism in Organic Chemistry by Petersykes
12. Stereochemistry and Mechanism through Solved Problems by P.S. Kalsi.
13. Text book of Organic Chemistry by P.S. Kalsi.
14. F.A. Carey and Sundberg, Advanced Organic Chemistry – Part A & B, 3rd edition, Plenum Press, New York, 1990.
15. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd edition, Wiley Eastern Limited, New Delhi, 1991.

16. S.K. Ghosh, Advanced General Organic Chemistry, Book and Alleied (P) Ltd, 1998.
17. Heterocyclic Chemistry – Joule & Smith
18. Heterocyclic Chemistry – Achaeson
19. Basic Principles of Heterocyclic Chemistry – L.A. Pacquette
20. Comprehensive Heterocyclic Chemistry – Kartritzky series, Pergamon Press, New York, 1984.

PHYSICAL CHEMISTRY-I

UNIT-I

Classical Chemical Thermodynamics

Concepts of Entropy and Free energy: A brief resume of laws of thermodynamics (First and second laws). Entropy as a measure of unavailable energy. Entropy change during spontaneous process. Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Maxwell's relations. Third law of thermodynamics - Nernst heat theorem & its applications. Determination of absolute entropies.

Thermodynamics of simple mixtures: Partial molar volumes and their determination by intercept method and density measurements. Chemical potential and its significance. Variation of chemical potential with temperature and pressure. Formulation of the Gibbs - Duhem equation. Derivation of Duhem-Margules equation. Chemical potential of liquids-Ideal solution-Raoult's law and Ideal-dilute solutions-Henry's law. Applications of Raoult's and Henry's law. Thermodynamic properties of Ideal and Real solutions.

Fugacity: Concept of fugacity, Determination of fugacity of gases. Variation of fugacity with temperature and pressure. Activity and activity coefficients. Variation of activity with temperature and pressure. Determination of activity co-efficients by vapour pressure, depression in freezing point, solubility measurements and electrical methods.

Numerical Problems included wherever necessary. **13 Hours**

UNIT-II

Chemical Kinetics

Basic kinetic concepts: Scope, Stoichiometry, Rate, Order and Rate constant of reaction and Empirical Rate Equation.

Determination of rates and orders; Differential method and Integration method, isolation method, Half life method and Comparison method**.**

Kinetics of complex reactions: Parallel, Consecutive and Reversible Reactions (H_2-Halogen reactions).

Effect of Temperature: Arrhenius Equation, energy of activation and its experimental determination. **Theories of Reaction Rates:** Kinetic theory of Collision, Activated complex theory of reaction rate, classical thermodynamics treatment.

Elementary Gas-Phase reactions: Unimolecular Reactions-Lindemann-Christainsen Hypothesis, Hinshelwood's Treatment, Rice-Ramsperger-Kassel(RRK) Treatment & Marcus's Extension of the RRK Treatment(RRKM). **13 Hours**

UNIT-III

Electrochemistry

Arrhenius theory of strong and weak electrolytes and its limitations, Debye-Huckel theory of strong electrolytes, Debye Huckel-Onsager equation, Debye-Huckel limiting equation for activity co-efficients, Debye-Huckel equation for appreciable concentrations. Bjerrum theory of ion association-triple ion and significance. Walden`s rule and its application.

Electrical Double layer Theories: A brief survey of Helmholtz-Perrin, Gouy-Chapman and Stern electrical double layer,

Transport Number: Determination of transport number by Hittorf method and e.m.f method. True and apparent transport numbers. Abnormal transport numbers, effect of temperature and concentration on transport number.

Irrversible electrode process: Introduction, reversible and irreversible electrodes, reversible and irreversible cells. Polarization, over voltage - ohmic over voltage, concentration over voltage activation over voltage, experimental determination of over voltage. Equations for concentration over potential, diffusion current – stationary current, potential curves, thickness of diffusion layer, diffusion controlled current – potential curves at a dropping mercury electrode, polarography, half wave potential, application in qualitative and quantitative analysis. Energy barrier and electrode kinetics, Butler-Volmer equation, Tafel equation. Hydrogen over voltage and Oxygen over voltage. Effect of temperature, current density and *p*H on over voltage.

Numerical Problems included wherever necessary.

UNIT-IV

Molecular Spectroscopy

Microwave spectroscopy: Rotation spectra of diatomic Molecules - rigid and non rigid rotator model. Rotational quantum number and the selection rule. Effect of isotopic substitution on rotation spectra. Relative intensities of the spectral lines. Classification of polyatomic molecules based on moment of

inertia - Linear, symmetric top, asymmetric top and spherical molecules. Rotation spectra of polyatomic molecules (OCS, CH_3F and BCl_3). Moment of inertia expression for linear tri-atomic molecules. Applications - Principles of determination of Bond length and moment of inertia from rotational spectra. Stark effect in rotation spectra and determination of dipole moments.

Vibration spectroscopy: Vibration of diatomic molecules, vibrational energy curves for simple harmonic oscillator. Effects of anharmonic oscillation. Vibration - rotation spectra of carbon monoxide. Expressions for fundamental and overtone frequencies. Vibration of polyatomic molecules – The number of degrees of freedom of vibration. Parallel and perpendicular vibrations (CO_2 and H_2O). fundamental, overtone, combination and difference bands. Fermi resonance. Force constant and its significance. Theory of infrared absorption and theoretical group frequency. Intensity of absorption band and types of absorptions. Correlation chart. Important spectral regions - hydrogen stretching region, double and triple bonds regions, fingerprint region. Factors affecting the group frequency – Physical state, vibrational coupling, electrical effect, hydrogen bonding, steric effect and ring strain. Applications: Structures of small molecules: XY_2 – linear or bent, XY_3 – planar or pyramidal. **13 Hours**

References:

1. Chemical thermodynamics by F. T. Wall, W. H. Freeman & Co.
2. Elements of Classical and Statistical Thermodynamics by L.K. Nash, Addison-Wesley (1970).
3. Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
4. Text Book of Physical Chemistry by Samuel Glasstone, McMillan Indian Ltd., 2nd edition (1974).
5. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990).
6. Principles of Physical Chemistry-Puri, Sharma, Pathania, Vishal Publishing Co.
7. Modern Electrochemistry Vol. I & II, J. O. M. Bockris & A. K. N. Reddy, Plenum.
8. An Introduction to Electrochemistry by Glasstone. S, Affiliated East West press, New Delhi. (2004)
9. Chemical Kinetics – L.K. Jain.
10. Chemical Kinetics – Benson.
11. Fundamentals of molecular spectroscopy-C. N. Banwell
12. Physical Chemistry by Alberty and Silby, Jolly Wiley.

PRACTICALS

ANALYTICAL CHEMISTRY PRACTICALS

PART – I

1. Determination of total acidity of vinegar and wines by acid-base titration.
2. Determination of purity of a commercial boric acid sample, and Na_2CO_3 content of washing soda.
3. Analysis of chromate-dichromate mixture by acid-base titration.
4. Determination of replaceable hydrogen and relative molecular mass of a weak organic acid by titration with NaOH.
5. Determination of ephedrine and aspirin in their tablet preparations by residual acid-base titrimetry.
6. Determination of purity of aniline and assay of chlorpromazine tablets by non-aqueous acid-base titration.
7. Periodate determination of ethylene glycol and glycerol (Malprade reaction).
8. Determination of carbonate and bicarbonate in a mixture by *p*H-metric titration and comparison with visual acid-base titration.
9. Determination of purity of a commercial sample of mercuric oxide by acid-base titration.
10. Determination of benzoic acid in food products by titration with methanolic KOH in chloroform medium using thymol blue as indicator.
11. Determination of the *p*H of hair shampoos and *p*H determination of an unknown soda ash.
12. Analysis of water/ waste water for acidity by visual, *p*H metric and conductometric titrations.
13. Analysis of water/ waste water for alkalinity by visual, *p*H metric and conductometric titrations.
14. Determination of carbonate and hydroxide-analysis of a commercial washing soda by visual and *p*H-titrimetry.
15. Determination of ammonia in house-hold cleaners by visual and conductometric titration.
16. Potentiometric determination of the equivalent weight and Ka for a pure unknown weak acid.
17. Spectrophotometric determination of creatinine and phosphorus in urine.
18. Flame emission spectrometric determination of sodium and potassium in river/ lake water.
19. Spectrophotometric determination of *p*Ka of an acid-base indicator.

PART – II

1. Determination of percentage of chloride in a sample by precipitation titration - Mohr, Volhard and Fajan's methods.
2. Determination of silver in an alloy and Na_2CO_3 in soda ash by Volhard method.
3. Mercurimetric determination of blood or urinary chloride.
4. Determination of total hardness, calcium and magnesium hardness and carbonate and bicarbonate hardness of water by complexation titration using EDTA.
5. Determination of calcium in calcium gluconate/ calcium carbonate tablets/ injections and of calcium in milk powder by EDTA titration.

6. Analysis of commercial hypochlorite and peroxide solution by iodometric titration.
7. Determination of copper in an ore/ an alloy by iodometry and tin in stibnite by iodimetry.
8. Determination of ascorbic acid in vitamin C tablets by titrations with $KBrO_3$ and of vitamin C in citrus fruit juice by iodimetric titration.
9. Determination of iron in razor blade by visual and potentiometric titration using sodium metavanadate.
10. Determination of iron in pharmaceuticals by visual and potentiometric titration using cerium(IV) sulphate.
11. Determination of nickel in steel by synergic extraction and boron in river water/ sewage using ferroin.
12. Determination of total cation concentration of tap water by ion-exchange chromatography.
13. Determination of magnesium in milk of magnesium tablets by ion-exchange chromatography.
14. Cation exchange chromatographic separation of cadmium and zinc and their estimation by EDTA titration.
15. Gas chromatographic determination of ethanol in beverages.
16. Determination of aspirin, phenacetin and caffeine in a mixture by HPLC.
17. Solvent extraction of zinc and its spectrophotometric determination.
18. Anion exchange chromatographic separation of zinc and magnesium followed by EDTA titration of the metals.
19. Separation and determination of chloride and bromide on an anion exchanger.
20. Thin layer chromatographic separation of amino acids.

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Practical Clinical biochemistry methods and interpretations, R. Chawla, J.P. Bothers Medical Publishers (P) Ltd., 1995.
7. Laboratory manual in biochemistry, J. Jayaraman, New Age International Publishers, New Delhi, 1981.
8. Practical Clinical Biochemistry by Harold Varley and Arnold.Heinmann, 4th edition.

INORGANIC CHEMISTRY PRACTICALS

PART – I

1. Preparation of Metal Acetylacetonate Complexes (Copper, Cobalt, Manganese, Iron, Chromium). – Atleast any two complexes. Record and interpretation of UV-Vis, IR, Powder XRD and NMR spectra of complexes.
2. Preparation of Chloropentamminecobalt chloride $[Co(NH_3)_5Cl]Cl_2$. Record and interpretation of UV-Vis, IR and Powder XRD spectra of complexes.
3. Preparation of tris-(1,2-diaminoethane)chromium(III) chloride, $[Cr(en)_3]Cl_3$. Record and interpretation of UV-Vis, IR and Powder XRD spectra of complexes.
4. Preparation of hexaamminenickel(II) chloride. Record and interpretation of UV-Vis, IR and Powder XRD spectra of complexes.
5. Preparation of Metal Chalcone Complexes (Copper, Cobalt, Manganese, Iron, Chromium). – Atleast any two complexes. Record and interpretation of UV-Vis, IR, Powder XRD and NMR spectra of complexes.
6. Determination of the composition of iron-phenanthroline complex by:

(a) Job's method

(b) Mole-ratio method and

(c) Slope-ratio method.

7. Circular paper chromatographic separation of: (Demonstration)

a. Iron and nickel

b. Copper and nickel

Chloropentamminecobalt chloride

PART – II

Semimicro qualitative analysis of mixtures containing **TWO** anions and **TWO** cations (excluding sodium, potassium and ammonium cations) and **ONE** of the following less common cations: W, Mo, Ce, Th, Ti, Zr, V, U and Li.

References:

1. Vogel's Text Book of Quantitative Chemical Analysis – 5th edition, J. Basset, R.C. Denney, G.H. Jeffery and J. Mendhom.
2. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel, 3rd edition.
3. Spectrophotometric Determination of Elements by Z. Marczenko.
4. Vogel's Qualitative Inorganic Analysis – Svelha.
5. Macro and Semimicro Inorganic Qualitative Analysis by A.I. Vogel.
6. Semimicro Qualitative Analysis by F.J. Welcher and R.B. Halin.
7. Quantitative Chemical Analysis by Daniel C. Harris, 7th edition, (2006).

ORGANIC CHEMISTRY PRACTICALS

PART – I

1. Preparation of *p*-nitro aniline from acetanilide (Nitration reaction).
2. Preparation of n-butyl bromide from n-butanol **(**Nucleophilic Substitution reaction SN^2**).**
3. Preparation of *p*-nitroiodobenzene from paranitroaniline (Sandmeyer reaction).
4. Preparation of aniline from nitrobenzene (Reduction reaction).
5. Preparation of phenoxy acetic acid.
6. Preparation of cyclohexanone from cyclohexanol (Chapman-Stevens Oxidation).
7. Preparation of chalcone (Claisen–Schmidt condensation).
8. Preparation of *S*-benzylthiuronium chloride.
9. Condensation of anthracene and maleic anhydride (Diels-Alder reaction).
10. Preparation of m-nitrobenzoic acid from methyl benzoate.

PART – II

Qualitative analysis: Separation of binary mixtures, identification of functional groups and preparation of suitable solid derivatives.

Reference Book

1. Vogel's Text Book of Quantitative Chemical Analysis – 5th edition, J. Basset, R.C. Denney, G.H. Jeffery and J. Mendhom.
2. Manual of Organic Chemistry - Dey and Seetharaman.
3. Modern Experimental Organic Chemistry by John H. Miller and E.F. Neugil.
4. An Introduction to Practical Organic Chemistry -Robert, Wingrove etc
5. A Text Book of Practical Organic Chemistry A.I. Vogel, Vol.III
6. Practical Organic Chemistry -Mann & Saunders.
7. Semimicro Qualitative Organic Analysis by Cheronis, Entrikin and Hodnet
8. Comprehensive Practical organic chemistry Quantitative Analysis V K Ahluwalia, Sunita dhingra.
9. Comprehensive Practical organic chemistry Qualitative Analysis V K Ahluwalia, Sunita dhingra.

PHYSICAL CHEMISTRY PRACTICALS – I

Non-Instrumental

1. Kinetics of the Iodine-hydrogen peroxide clock reaction.
2. Study of kinetics of hydrolysis of an ester using HCl/ H_2SO_4 at two different temperature, determination of rate constants and energy of activation.
3. Determination of activation energy for the bromide-bromate reaction.
4. Reaction between potassium persulphate and potassium iodide, determine the rate constant and energy of activation.
5. Determination of heat of solution of benzoic acid by variable temperature method (graphical method).
6. Determination of partial molar volume of NaCl-H_2O system.
7. Binary analysis of two miscible liquids by viscometric method (KCl/KNO_3/KBr/NaCl/Ethanol & Water).
8. Determination of molecular weight of polymer by viscosity method.
9. Verification of F & L adsorption isotherms for acetic acid on activated charcoal.
10. Determination of molecular weight and size parameters of polymers by viscometry.

Instrumental

11. Conductometric titration of a mixture of HCl and CH_3COOH against NaOH.
12. Conductometric titration of Orthophosphoric acid /Formic acid/ Oxalic acid against NaOH and NH_4OH.
13. Determination of PI of glycine by potentiometric method.
14. Determination of dissociation constant of a weak acid by potentiometric method.
15. *p*H titration of (a) polybasic acid(H_3PO_4), or (CH_3COOH+HCl) or $CuSO_4$ *vs* NaOH and determination of k_a.
16. To obtain the absorption spectra of coloured complexes, verification of Beer's law and estimation of Ni^{+2} ions from $[Ni(NH_3)_6]^{2+}$ by using Spectrophotometer.
17. Analysis of binary mixture (Glycerol and Water) by the measurement of refractive index.
18. Study the kinetics of reaction between CAT and indigocarmine spectrophotometrically and determination of rate constant.
19. Determine the equivalent conductance of strong electrolyte and verification of Onsager equation.
20. Verification of inverse square law using gamma emitter.

References:

1. Practical Physical Chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels *et al*.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico-Chemical Experiments – J. Rose.
7. Practical Physical Chemistry – S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994).
11. Experimental Physical Chemistry – R.C. Das. and B. Behera, Tata Mc Graw Hill.

SEMESTER-II

SEPARATION TECHNIQUES

UNIT I

Solvent extraction: Theory - Nernst partition law, efficiency and selectivity of extraction.

Extraction systems**:** Extraction of covalent neutral molecules, extraction of uncharged metal chelates and synergic extraction, extraction of ion-association complexes - non chelated complexes, chelated complexes and oxonium systems. Use of salting out agents. Methods of extraction - batch and continuous extractions. applications.

Solid Phase Extraction (SPE): Principles, apparatus and instrumentation. Solid phase sorbents, extraction formats - Automated solid phase extraction. Solid phase micro extraction (SPME). Applications of SPE and SPME.

Supercritical fluid extraction: Properties of supercritical fluids, Advantages of supercritical fluid extraction, instrumentation, supercritical fluid choice, off-line and on-line extractions, typical applications of supercritical fluid extraction.

UNIT II

Chromatography: Definition, principles and mechanism of separation, classification of chromatographic techniques. General descriptions of column chromatography - frontal analysis, displacement analysis and elution analysis. General theory of column chromatography: characterizing a chromatogram - retention time, retention volume and baseline width. Chromatographic resolution, capacity factor, column selectivity. Column efficiency - band broadening - rate theory and plate theory. Peak capacity, non ideal behavior. Optimizing chromatographic separations using capacity factor, column selectivity and column efficiency - Van Deemter equation, and its modern versions, Golay equation and Huber-Knox equations.

Thin layer chromatography: Principle, apparatus and methodology, applications, HPTLC

UNIT III

High performance liquid chromatography (HPLC): Principles, instrumentation - columns (analytical and guard columns), stationary phases, mobile phases, choosing a mobile phase, isocratic *vs* gradient elution, HPLC plumbing, sample introduction. Detectors for HPLC - spectroscopic, electrochemical and others, quantitative applications. Preparative HPLC-Applications.

Gas chromatography (GC): Principles, instrumentation - mobile phase, chromatographic columns, stationary phases, sample introduction, temperature control, and detectors for gas chromatography. Quantitative and qualitative applications.

Ion exchange chromatography (IEC): Definitions, requirements for ion-exchange resin, synthesis and types of ion-exchange resins, principle, basic features of ion-exchange reactions, resin-properties-ion-exchange capacity, resin selectivity and factors affecting the selectivity, applications of IEC in

preparative, purification and recovery processes. IEC with eluent suppressor columns. Single Column Ion Chromatography.

UNIT IV

Size-exclusion chromatography: Theory and principle of size-exclusion chromatography, experimental techniques of gel-filtration chromatography (GFC) and gel-permeation chromatography (GPC), materials for packing - factors governing column efficiency, methodology and applications.

Affinity chromatography: Definitions, separation-mechanism-matrices, matrix activation, role of spacer arms and applications.

Supercritical fluid chromatography (SFC): Principle, Instrumentation and operating variables, comparison of SFC with other types of chromatography, applications.

Electrophoretic methods - Electrophoresis**:** Theory - electrophoretic mobility, electroosmotic mobility, electroosmotic flow velocity, total mobility, migration time, efficiency, selectivity and resolution. Instrumentation, Capillary electrophoresis methods - capillary zone electrophoresis, micellar electrokinetic capillary chromatography, capillary gel electrophoresis and capillary electrochromatography.

References

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Introduction to Instrumental Analysis, Robert. D. Braun, Pharm. Med. Prem. India, 1987.
7. Instrumental Method of Analysis, W.M. Dean and Settle, 7th edition, 1986, CBS Publishers, New Delhi.
8. Instant Notes of Analytical Chemistry, Kealey and Haines, Viva Books Pvt. Ltd., 2002.
9. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.
10. Principles and Practice of Analytical Chemistry, F. W. Fifield and Kealey, 5th edition, 2000, Blackwell Sci., Ltd. Malden, USA.

INORGANIC CHEMISTRY-II

UNIT – I

Compounds of hydrogen:

The hydrogen and hydride ions, Dihydrogen and hydrogen bonding. Classes of binary hydrides: Molecular hydrides, saline hydrides and metallic hydrides.

The Group elements:

Occurrence, extraction and uses of **group 1 elements**. Simple compounds: Hydrides, halides, oxides, hydroxides, oxoacids, nitrides, solubility and hydration and solutions in liquid ammonia. Coordination and organometallic compounds. Applications.

Occurrence, extraction and uses **group 2 elements**. Halides, hydrides and salts of oxoacids. Complex ion in aqueous solution and complexes with amido and alkoxy ligands.

Lanthanides and actinides:

Electronic structure, oxidation states, extraction and separation of lanthanides, stereochemistry, spectral and magnetic properties of lanthanide and actinide complexes, lanthanide complexes as NMR shift reagents. Comparison with d-block ions.

[13 hours]

UNIT II

Theories of acids and bases – Bronsted and Lewis acids and bases, Lux-Flood theory, gas phase vs. solution acidity, solvent leveling effects, hardness and softness, HSAB concept. Symbiosis. Applications of HSAB concept.

Reactions in non-aqueous media: Liquid ammonia, anhydrous sulphuric acid, glacial acetic acid, anhydrous HF, bromine trifluoride, liquid sulphur dioxide and dinitrogen tetroxide.

Halogens and Noble gas chemistry –interhalogens, psuedohalogens, polyhalide ions, oxyhalogen species, xenon oxides and fluorides.

Supercritical fluids: Properties of supercritical fluids and their uses as solvents. Supercriticalfluids as media for inorganic chemistry

[13 hours]

Unit III

Crystal field theory of coordination compounds, d-orbital splitting in octahedral, square planar and tetrahedral fields, spectrochemical series, Jahn-Teller effect. Demerits of CFT.

MO theory of coordination compounds - MO energy level diagrams for octahedral and tetrahedral complexes with and without Pi bonding

Spectral properties of complexes: Term symbols for d^n ions, spectroscopic ground states, selection rules, nature of spectral bands- band shapes, band intensities, band widths, spin-orbit coupling, vibrational structures. Orgel diagrams, Tanabe-Sugano diagrams, interpretation of spectra of octahedral, distorted octahedral, tetrahedral and square planar complexes. Charge transfer bands – origin, types, and characteristics.

[13 hours]

Unit IV

Magnetic properties of complexes : Type of magnetic behaviour, orbital contribution, spin orbit coupling, measurement of magnetic susceptibility – Gouy and Faraday methods, diamagnetic corrections, ferro- and antiferromagnetic coupling, spin cross-over systems.

Chemistry of higher boranes, classification, structures and bonding, framework electron counting, Wade's rules, styx number, chemistry of B_5H_9, $B_{10}H_{14}$ and $B_nH_n^{2-}$. carboranes and metallocarboranes.

Cyclophosphazenes, phosphazene polymers, P-O and P-S cage compounds.

S-N compunds : binary sulphur nitrides- S_4N_4, S_2N_2 and $(SN)_x$.

Borazines and boron nitride,

Intercalation compounds of graphite, Silicates

The isolobal principles.

[13 hours]

References:

1. Basic Organometallic Chemistry - B.D. Gupta and A.J. Elias, Universities Press (2010).
2. Organometallics - A Concise Introdution, 2nd edition, Chistoph Elschenbroich and Albert salzer VCH, (1992).
3. Inorganic Chemistry, 2nd edition, C.E. Housecroft and A.G. Sharpe, Pearson Education Ltd., (2005).
4. Inorganic Chemistry- 3rd edition, G.L. Miessler and D.A. Tarr, Pearson Education, (2004).
5. Inorganic Chemistry, 4th edition. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Oxford University Press (2004).
6. Physical Inorganic Chemistry - A Coordination Chemistry Approach- S.F.A. Kettle, Spektrum, Oxford, (1996).
7. Inorganic Chemistry - 2nd edition, D.F. Shriver, P.W. Atkins and C.H. Langford, Oxford University Press, (1994).
8. Inorganic Chemistry- 3rd edition, James E. Huheey, Harper and Row Publishers, (1983).
9. Basic Inorganic Chemistry- 3rd edition, F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons, (2002).

Reagents, Heterocycles and Sterochemistry

UNIT –I

Conformational isomerism: Elementary account of conformational equilibria of ethane, butane and cyclohexane. Conformation of cyclic compounds such as cyclopentane, cyclohexane, cyclohexanone derivatives and decalins. Conformational analysis of 1,2, 1,3, and 1,4-disubstituted cyclohexane derivatives and *D*-Glucose, Effect of conformation on the course/ rate of reactions.

Nomenclature of organic compounds, Fused polycyclic hydrocarbons, Bridged polycyclic hydrocarbons, Bridged fused systems, Spirocyclic hydrocarbon systems, Heterocyclic systems,Metal organic compounds. Stereochemical nomenclature, prostereoisomerism, stereotopicity and stereoprojections.Non-carbon chiral centres.

Introduction to ORD, CD configuration and their application in assigning configuration and conformation.Octant and axial haloketone rules.Cotton effect.Stereochemistry of nitrogen and phosphorus containing compounds.Atropisomerism and its designation.Stereoselectivity, enantiomeric excess and chiral separation methods.Conformational analysis of alkanes, cycloalkanes and biased systems.Effect of conformation on reactivity of cyclohexane and decalin derivatives.Chiral drugs.

13Hrs

UNIT – II

Heterocyclic chemistry: Nomenclature of heterocyclic systems

Structure, reactivity, synthesis and reactions of indole, pyridine, benzofuran, quinoline, isoquinoline, pyrazole, imidazole, pyrone, coumarin, chromones, pyrimidines and purines.Synthesis and synthetic applications of azirines and aziridines, isoxazole and azepine.

13Hrs

UNIT –III

Reduction: Catalytic hydrogenations (homogeneous and heterogeneous)-catalysts, reduction of functional groups, catalytic hydrogen transfer reactions.Wilkinson catalyst.Baker's yeast, $LiAlH_4$, $NaBH_4$, metal dissolving reactions (Birch reduction).Leukart reaction (reductive amination),diborane, Meerwein-Ponndorf-Verley reduction, Wolf-Kishner reduction,Clemensen reduction.

Oxidation: Oxidation with chromium and manganese compounds (CrO_3, $K_2Cr_2O_7$, PCC, PDC, Sarret reagent, Jones reagent, MnO_2, $KMnO_4$), ozone, peroxides and peracids, lead tetra acetate, periodic acid, OsO_4, SeO_2, NBS, chloramine-T, Sommelet oxidation, Oppenauer oxidation.

Unit - IV

Reagents in organic synthesis: Use of following reagents in organic synthesis and functional group transformations: Lithium disopropylamide (LDA), Gilmann reagent, dicyclohexylcarbodimide (DCC),

dichlorodicyanoquinone (DDQ), trialkylsilyl halides, phase transfer catalyst, crown ethers, Fenton's reagent, Ziegler-Natta catalyst, diazomethane, tributyltinhydride, stannous chloride.

13Hrs

References:

1. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mac Grow Hill, New York, 1987.
2. Organic Chemistry - Morrison and Boyd
3. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. 1 & II, 1984.
4. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
5. E.S. Gould, Mechanism and Structure in Organic Chemistry, Halt, Rinhart & Winston, New York, 1964.
6. F.A. Carey and Sundberg. Advanced Organic Chemistry – Part A & B, 3rd edition, Plenum Press, New York. 1990.
7. Principles of Organic Synthesis - ROC Norman and Coxon
8. S.K. Ghosh, Advanced General Organic Chemistry, Book and Allied (P) Ltd. 1998.

PHYSICAL CHEMISTRY-II

UNIT-I

Quantum Chemistry

A brief resume of black body radiation, and atomic spectra-Bohr's theory of hydrogen atom. Photoelectric and Compton effects, de-Broglie concept, uncertainty principle, operators (algebra of operators, commutative and non-commutative operators, linear operator, Laplacian operator, Hermitian operator-Hamiltonian operator, turn over rule. Wave equation for stretched strings, Schrodinger wave equation for particles, Eigen values and Eigen functions, postulates of quantum mechanics. Application of Schrodinger equation to a free particle and to a particle trapped in a potential field (one dimension and three dimensions). Degeneracy, Wave equation for H-atom, separation and solution of R, ϕ and θ equations. Application of Schrodinger equation to rigid rotator and harmonic oscillator. Quantum numbers and their characteristics, orbital diagrams.

Approximate methods – Necessity of approximate methods, perturbation method, the theory of perturbation method – first order and second order correction, application to He-atom (first order correction only) – calculation of first ionization potential and binding energy. **13 Hours**

UNIT-II

Electrochemistry

Energetics of cell reactions: Effect of temperature, pressure and concentration on energetic of cell reactions (calculation of ΔG, ΔH and ΔS).

Advanced Electrochemical Techniques: Principles, Instrumentation-Electrochemical scanning tunneling microscopy and Electrochemical Atomic force microscopy. Spectro-electrochemistry - Principle, applications. Electrochemical Impedance Impedance measurements: Nyquist and Bode Plots, Chronomethods - Principles, Chronopotentiometric –amperometric and coulometric measurements - Instrumentation and Applications.

Corrosion: Corrosion- definition, Classification-chemical and electrochemical corrosion. Theories of corrosion, Local cell theory (Wagner and Traud theory). Corrosion current and polarization phenomena – Exchange current density – Polarization techniques to measure corrosion rates. Current – potential relations (Evan diagram) in corrosion cells. Factors affecting the rate of corrosion-nature of metal, nature of corrosion product, relative areas of anode and cathode, temperature and pH. Types of corrosion – differential metal corrosion, differential aeration corrosion (pitting and waterline corrosion), stress corrosion-caustic embrittlement in boilers.

Corrosion control – Cathodic protection- sacrificial anode and impressed current techniques, Anodic protection. Protective coatings-Inorganic coatings-anodizing and phosphating, metal coating- galvanizing and tinning. Corrosion inhibitors-cathodic and anodic inhibitors. **13 Hours**

UNIT-III

Thermodynamics

Irreversible Thermodynamics:

Thermodynamic criteria for non-equilibrium states. Entropy production in chemical reactions. Transformations of the generalized fluxes and forces, non-equilibrium stationary states, phenomenological equations. Microscopic reversibility and Onsager`s reciprocity relations. Irreversible thermodynamics for biological systems and non-linear regime.

(Numerical Problems included wherever necessary).

Statistical thermodynamics:

Micro and macro states, phase and ensembles. Thermodynamic probability and most probable distribution–Maxwell-Boltzmann distribution law. Maxwell-Boltzmann, statistics and applications, Bose-Eistein and Feimi-Dirac Statistics. Partition functions–definition, evaluation of translational, rotational

and vibrational and electronic for monoatomic gaseous molecules. Calculation of thermodynamic functions and equilibrium constants in terms of partition functions, entropy of monoatomic gases. Sackur-Tetrode equation. Comparison of third law and Statistical entropies. **13 Hours**

UNIT-IV

Molecular Spectroscopy

Raman spectroscopy: Introduction, Raman and Rayleigh scattering, Stokes and anti-Stokes lines, polarization of Raman lines, depolarization factor, polarizability ellipsoid. Theories of Raman spectra - classical and quantum theory. Rotation-Raman and vibration-Raman spectra. Comparison of Raman and IR spectra, rule of mutual exclusion principle. Vibration modes of some simple molecules and their activity in Raman.

UV Visible spectroscopy: Quantitative aspects of absorption – Beer's law, Technology associated with absorption measurements. Limitations of the law – real, chemical, instrumental and personal. Theory of molecular absorption. Vibration rotation fine structure of electronic spectra. Types of absorption bands- n to π^*, π to π^*, n to σ^* and σ to σ^*, C-T and ligand field.

NQR Spectroscopy: Quadrupolar nuclei, electric field gradient, nuclear quadrupole coupling constants, energies of quadrupolar transitions, effect of magnetic field. Applications.

Mössbauer spectroscopy: The Mössbauer effect, chemical isomer shifts, quadrupole interactions, measurement techniques and spectrum display, application to the study of Fe^{2+} and Fe^{3+} compounds, Sn^{2+} and Sn^{4+} compounds, nature of M-L bond, coordination number and structure), detection of oxidation states and inequivalent Mössbauer atoms.

Electron Spin Resonance Spectroscopy: Basic principles, hyperfine couplings, the 'g' values, factors affecting 'g' values, isotropic and anisotropic hyperfine coupling constants, Zero Field splitting and Kramer's degeneracy. Measurement techniques and Applications to simple inorganic and organic free radicals and to inorganic complexes.

13 Hours

References:

1. Introduction to Quantum Chemistry-A. K. Chandra, Tata McGraw Hill.
2. Principles of Physical Chemistry-Puri, Sharma, Pathania, Vishal Publishing Co.
3. Molecular quantum mechanics, Vol. I & II, P. W. Atkins, Oxford university presss.
4. Chemical thermodynamics by F. T. Wall, W. H. Freeman & Co.
5. Statistical Thermodynamics by B.C. Mclelland, Chapman and Hall, London (1973).

6. Elementary Statistical Thermodynamics by N.D. Smith, Plenum Press, NY (1982).
7. Elements of Classical and Statistical Thermodynamics by L.K. Nash, Addison-Wesley (1970).
8. Introduction to Statistical Thermodynamics by M. Dole, Prantice Hall, (1962).
9. Modern Electrochemistry Vol. I & II, J. O. M. Bockris & A. K. N. Reddy, Plenum.
10. An Introduction to Electrochemistry by Glasstone. S, Affiliated East West press, New Delhi. (2004)
11. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990).
12. Fundamentals of molecular spectroscopy-C. N. Banwell
13. Physical Chemistry by Alberty and Silby, Jolly Wiley.

PRACTICALS

Analytical Chemistry and Inorganic Chemistry

[128 HOURS EACH]

[OR]

Organic Chemistry and Physical Chemistry

[128 HOURS EACH]

Experiments are as in FIRST SEMESTER. Every student will carry out experiments on a rotation basis in the FIRST and SECOND semesters.