

**MASTER OF SCIENCE IN
CHEMISTRY**
(SEMESTER PATTERN) CHOICE BASED
CREDIT SYSTEM SYLLABUS
TWO YEARS FULL TIME PROGRAMME

COURSE OF STUDIES
(As per U.G.C. Model Syllabus)



P.G. DEPARTMENT OF CHEMISTRY
S.C.S (A) COLLEGE, PURI

2017-2019



S.C.S. (AUTONOMOUS) COLLEGE, PURI COURSES OF STUDIES FOR THE M.Sc. EXAMINATION IN CHEMISTRY, 2017-19

As per the UGC model syllabus, the choice based credit system syllabus in M.Sc. Chemistry shall comprise of four semesters, having total of 2000 marks and 80 credits. There shall be 16 theory papers and 4 practical papers, four credit each. Each theory paper consists of mid-sem of 30 marks and end-sem of 70 marks. Duration of mid-sem is 1.5 hrs and duration of end-sem is 3 hrs. There shall be 4 practical papers each carrying 100 mark and of 6hrs duration.

Questions will be set unit wise. Each unit will carry 2 questions. Students are required to answer 5 questions with one question from each unit. The paper will comprise of both subjective and objective questions (Problem oriented approach should be there).

**Distribution of courses in Semester Pattern under Choice Based Credit System for M.Sc. (Chemistry)
Programme effective from - 2017-18**

SEMESTER – I

<i>Core Paper</i>	Subject (Paper)	Code	Credit	Full Marks	TOTAL FULL MARKS
Theory	Inorganic Chemistry and spectroscopy	CH - 1.1	4	70+30	500
Theory	Organic Chemistry	CH – 1.2	4	70+30	
Theory	Physical Chemistry	CH – 1.3	4	70+30	
Theory	Computer for Chemists	CH – 1.4	4	70+30	
<i>PRACTICAL</i>					
	Inorganic and Organic Chem. lab	CH - 1.5	4	100	

SEMESTER II

<i>Core Paper</i>	Subject (Paper)	Code	Credit	Full Marks	TOTAL FULL MARKS
Theory	Inorganic and Analytical Chemistry	CH – 2.1	4	70+30	500
Theory	Organic Chemistry	CH – 2.2	4	70+30	
Theory	Physical Chemistry	CH – 2.3	4	70+30	
Theory	Spectroscopy	CH – 2.4	4	70+30	
<i>PRACTICAL</i>					
	Inorganic and Organic Chem. Lab.	CH – 2.5	4	100	

SEMESTER III

<i>Core Paper</i>	Subject (Paper)	Code	Credit	Full Marks	TOTAL FULL MARKS
Theory	Photo Chemistry and Spectroscopy	CH – 3.1	4	70+30	500
Theory	Bioinorganic & Supramolecular Chemistry	CH – 3.2	4	70+30	
Theory	Bioorganic Chemistry	CH – 3.3	4	70+30	
Theory	Environmental Chemistry	CH – 3.4	4	70+30	
<i>PRACTICAL</i>					
	Physical and Analytical Chemistry Lab.	CH – 3.5	4	100	

SEMESTER IV

<i>Core Elective Papers</i>	Subject (Paper)	Code	Credit	Full Marks	TOTAL FULL MARKS
Theory	Organic synthesis	CH – 4.1	4	70+30	500
Theory	Polymer Chemistry	CH – 4.2	4	70+30	
Theory	Solid State Chemistry	CH – 4.3	4	70+30	
Theory	Applications of Spectroscopy	CH – 4.4	4	70+30	
<i>PRACTICAL</i>	Polymer and Physical chemistry Lab.	CH – 4.5	4	100	
TOTAL PAPERS=20	TOTAL CREDIT =		80	TOTAL FULL MARKS	2,000

SEMESTER – I

CH – 1.1: INORGANIC CHEMISTRY AND SPECTROSCOPY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT – I Stereochemistry and Bonding in Main Group Compounds

VSEPR, Walsh diagrams (tri- and penta-atomic molecules), d_{π} - p_{π} bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.

UNIT – II Metal –Ligand Equilibria in Solution

Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH- metry and spectrophotometry.

UNIT – III Reaction Mechanism of Transition Metal Complexes

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution. Acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes. The trans effect, mechanism of one electron transfer reactions, outer sphere type reactions, cross reactions and Marcus-Hush theory, Inner sphere type reactions

UNIT – IV Electronic Spectroscopy

Atomic Spectroscopy: Energies of atomic orbitals, vector representation of momenta and vector coupling, Electronic configuration, Russell-Saunders terms and coupling schemes, magnetic effects: spin-orbit coupling and Zeeman splitting, spectra of hydrogen atom and alkali metal atoms.

Molecular Spectroscopy: Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules. Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.

UNIT – V Microwave Spectroscopy

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor. Stark effect, nuclear and electron spin interaction and effect of external field. Applications.

Photoelectron Spectroscopy

Basic principles; photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple molecules, ESCA, chemical information from ESCA. Auger electron spectroscopy – basic idea.

Books Recommended:-

For inorganic-

1. *Inorganic Chemistry*, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 4th Ed., Pearson Education (2006)
2. *Inorganic chemistry*, G. L. Miessler, D.A.Tarr, 3rd ed., Pearson Education 2004
3. *Inorganic Chemistry*, K.F. Purcell & J.C. Kotz, Cengage Learning, Indian Ed. 2010
4. *Advanced Inorganic Chemistry*, F. A. Cotton, M. Bochmann, C. A. Murillo, G. Wilkinson, 6th Ed., Wiley India (2007).

5. *Basic inorganic chemistry by Cotton, Wilkinson, 3rd edn, Wiley India*
6. *Fundamentals of inorganic chemistry by Asim K. Das., vol-2,4,5., 2nd edn, CBS PUBLISHERS*
7. *Principles of Inorganic chemistry by Puri, Sharma, Kalia., 5th edn, Vishal Publishers Pvt. Ltd.*
8. *Concepts and Models of Inorganic Chemistry, B. Douglas, D. McDaniel, J. Alexander, Wiley, 3rd Ed. (2006)*
9. *Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, Oxford University Press, 1998*
10. *F. Basolo & R. G. Pearson, Mechanism of Inorganic Reactions, Wiley Eastern (1967).*
11. *Shriver, D.F.; Atkins, P.W Inorganic Chemistry, 6th Edn., Oxford University, OUP*
12. *Inorganic Electronic Spectroscopy, A. B. P. Lever, Elsevier, 2nd Ed. (1984).*

For spectroscopy-

1. *Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).*
2. *Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press*
3. *Modern Spectroscopy, J.M. Hollas, John Wiley, 2004, 4th edition, Sussex.*
4. *Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L.Ho, Wiley Inter science.*
5. *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, 1990, 1st edition, Ellis Harwood.*
6. *Physical Methods in Chemistry, R.S. Drago, Saunders College.*
7. *Chemical Applications of Group Theory, F.A. Cotton.*
8. *Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill*
9. *Basic Principles of Spectroscopy, R. Chang, McGraw Hill.*
10. *Theory and Applications of UV Spectroscopy, H.H.Jaffe and M.Orchin, IBH-Oxford.*
11. *Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley*
12. *Fundamentals of Photochemistry-K.K.Rohatgi-Mukharjii, Wiley Eastern*
13. *J.R.Dyer. Application of absorption spectroscopy of organic compounds*
14. *Jaffe and Orchin, Theory and application of U.V,*

CHE – 1.2 : ORGANIC CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT – I Nature of Bonding in Organic Molecules

Delocalized chemical bonding-conjugation, cross conjugation, resonance, hyper conjugation, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of π - molecular orbitals, annulenes, antiaromaticity, ψ -aromaticity, homo-aromaticity, PMO approach. Bonds weaker than covalent addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, Catenanes and Rotaxanes.

UNIT-II Stereochemistry

Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding. Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotropic and diastereotropic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

UNIT III Reaction Mechanism: Structure, Reactivity and Rearrangements

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Hard and soft acids and bases.

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity- resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationships, substituent and reaction constants, Taft equation.

UNIT-IV

Rearrangements

General mechanistic considerations: nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements

Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-villiger, Shapiro reaction.

Aliphatic Electrophilic Substitution

Bimolecular mechanisms (S_E2) and S_{Ei} . The S_{E1} mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

UNIT V Aliphatic Nucleophilic Substitution

The S_N2 , S_N1 , mixed S_N1 and S_N2 and SET mechanisms.

The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance.

Classical and non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements.

Application of NMR spectroscopy in the detection of carbocations.

The S_N1 mechanism.

Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon.

Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

Books Recommended

1. *Organic synthesis: Clayden, Greeves, Warren and Wothers, Oxford Univ. Press, 2nd Ed (2012).*
2. *Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley, 6th Ed.(2006).*
3. *Organic synthesis by George f Zwiefel and Michiel h nantz*
4. *Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)*
5. *Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)*
6. *Modern Organic Reactions, H. O. House, W.A. Benjamin. 2nd Ed.(1972) Stereochemistry by Subrata Sen Gupta, oup india*
7. *Principles of Organic Synthesis, R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).*
8. *Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. Singh, Macmillan. 3rd*
9. *Stereochemistry of Organic Compounds, E. L. Eliel, S. H. Wilen, L.N.Mander, John Wiley*
10. *Stereochemistry of Organic Compounds. D.Nasipuri. New Age International.*
11. *Stereochemistry of Organic Compounds. P.S.Kalsi. New Age International*
12. *Reaction mechanism of organic chemistry by S Sen Gupta, oup, india*
13. *Organic reaction and their mechanism by P S Kalsi, . New Age International*
14. *Organic chemistry by S H pine, TMH, 5edn*
15. *Reactions Rearrangements and Reagents by S N Sanval Bharati Bhawan Fourth edition*
16. *Organic reaction mechanism by V.K Ahlwalia, R.K.Parashar, 4edn*

CHE - 1.3: PHYSICAL CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I

Quantum Chemistry

Introduction to Exact quantum Mechanical Results

Postulates of quantum mechanics, Schrodinger equation and discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotator, the hydrogen atom.

Approximate Methods

The variation theorem, linear variation principle. Perturbation theory (first order and non-degenerate). Applications of variation method and perturbation theory to the Helium atom.

Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigen functions for angular momentum, eigenvalues of angular momentum, operator using ladder operators, addition of angular moments, spin, antisymmetry and Pauli exclusion principle.

UNIT-II

Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Generators, Point symmetry group.

Representations of group operators, The great orthogonality theorem (without proof) and its explanation. Irreducible and reducible representation. Bases of representation, Character of a representation. Character table and its meaning. Reduction formula

UNIT-III

Molecular Orbital Theory

Huckel's theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Huckel theory.

Unifying Principles

Electromagnetic radiation, interaction of electromagnetic radiation with matter: absorption, emission, transmission, Uncertainty relation and natural line width and natural line broadening, transition probability, results of the time dependent perturbation theory, transition moment, and intensity of spectral lines

UNIT IV

Thermodynamics

Classical Thermodynamics

Concept of free energy, chemical potential and entropy, Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances and determinations. Concept of fugacity and determination of fugacity. Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient.

Non Equilibrium Thermodynamics

Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocal relations.

UNIT V

Statistical Thermodynamics

Thermodynamic probability concept of ensemble, Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers) Maxwell- Boltzmann, Bose-Einstein and Fermi Dirac statistics.

Partition functions-translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions. Heat capacity behaviour of solids-chemical equilibria and equilibrium constant in terms of partition functions, Fermi–Dirac statistics, applications to metal. Bose-Einstein statistics-application to helium. Bose-Einstein condensate.

Books Recommended

- Physical Chemistry, P.W. Atkins and J. D. Paulo, Oxford, 2013, 10th edition New Delhi.
- Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill, 1997, 4th edition, New Delhi.
- Quantum Chemistry, R.K. Prasad, New Age International (P) Ltd, 1985, 1st edition, New Delhi.
- Quantum Chemistry, Ira N. Levine, Pearson, 2007, 5th edition, New Delhi.,
- Quantum Chemistry, D. A. McQuarrie and J. D. Simon, Viva, 2007, 1st New Delhi
- Quantum Chemistry, J. P. Lowe, Academic Press, 2nd edition, New York.
- Physical Chemistry, T. Engel and P. Reid, Pearson, 2006, 1st edition, New Delhi.
- Thermodynamics, G. N. Lewis and M. Randall, McGraw Hill, 1961, 2edition, York.
- Molecular Thermodynamics, D. A. McQuarrie and J. D. Simon. Viva, 2009, 1st ed,
- Non Equilibrium Thermodynamics, S.R. deGroot and Mazur, Dover, New York
- Introductory Statistical Thermodynamics, T. Hill, Dover, 1986, New York.
- Statistical Thermodynamics, A. Maczek, Oxford Chemistry Primer vol. 58, OUP,
- Introduction to Statistical Mechanics, R. Bowley and M. Sanchez, Clarendon press,
- Statistical Mechanics and Thermodynamics, C. Garrod, Oxford Univ. Press, 1995,
- Statistical Thermodynamics, M.C. Gupta, Wiley Eastern Ltd. , 1990, New Delhi.
- Introduction to thermodynamics of irreversible processes, I. Prigogine, 2nd edition,
- Molecular Quantum mechanics by Atkins and Friedman, Oxford Univ. Press, 1997, 3rd
- Symmetry and group theory by K V Reddy, new age international
- Chemical application of group theory by F A COTTON
- M.S.Gopinathan and V.Ramakrishnan, Group Theory in Chemistry, Vishal Publishers
- Physical Methods in Chemistry, R S Drago, 2nd edn., Saunders, 1997

CHE – 1.4: COMPUTERS FOR CHEMISTS

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT – I **Computer Programming in C**

Elements of the computer language. Constants and variables. Operations and symbols. Expressions. Arithmetic assignment statement. Input and Output. Format statement. Termination statements. Branching statements such as IF or GO TO statement.

UNIT – II

LOGICAL variables. Double precision variables. Subscripted variables and Dimension. DO statement. FUNCTION and SUBROUTINE. COMMON and DATA statements. (Students learn the programming logic and these language features by 'hands on' experience on a personal computer from the very beginning of this topic).

UNIT – III **Programming in Chemistry**

Development of small computer codes involving simple formulae in chemistry, such as van der Waals equation, pH titration, kinetics, radioactive decay. Evaluation of lattice energy and ionic radii from experimental data. Linear simultaneous equations to solve secular equations within the Huckel theory. Elementary structural features such as bond lengths, bond angles, dihedral angles etc. of molecules extracted from a database such as Cambridge data base.

UNIT – IV **Use of Computer Programmes-I**

The students will learn how to operate a PC and how to run standard programmes and packages. Execution of linear regression, X-Y plot, numerical integration and differentiation as well as differential equation solution programmes.

UNIT – V **Use of Computer Programmes-II**

Programmes with data preferably from Physical Chemistry Laboratory. Further, the students will operate the packages MS- WORD, POWER POINT AND EXCEL.

Books Recommended

1. Computers and Common Sense, R. Hunt and J. Shelley, Prentice Hall
2. Computational Chemistry, A.C. Norris.
3. Microcomputer Quantum Mechanics, J.P. Killngbeck, Adam Hilger.
4. Computer Programming in FORTRAN IV, V, Rajaraman, Prentice Hall.
5. An Introduction to Digital Computer Design, V. Rajaraman and T. Radhakrishnan, Prentice Hall

INORGANIC CHEMISTRY

- (a) Mixture Analysis
- (b) Less Chromatography common metal ions – Mo, W, Ti, V, U (two metal ions in cationic / anionic forms)
- (c) Insoluble – oxides, sulphates and halides

Separation of cations and anions by

- (a) Paper Chromatography
- (b) Column Chromatography – Ion exchange.

ORGANIC CHEMISTRY

Qualitative Analysis

Identification of unknown organic compounds, separation, purification and identification of compounds of binary mixture (both are solids, one liquid & one solid) using TLC & column chromatography, Chemical tests. IR spectra to be used for functional group identification.

Books recommended for inorganic chemistry lab.

1. Inorganic Experiments, J. Derck Woollins., VCH
2. Microscale Inorganic Chemistry, Z.Szafran, R.M. Pike and M.M.Singh, Wiley.
3. Practical Inorganic Chemistry, G.Marr and B.W.Rockett, Van Nostrand.
4. An Advanced Course of Practical Chemistry, Nad, Ghosal & Mahapatra, Central Publisher (2000).
5. Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed, Person (2007).

Books Recommended for Organic Chemistry lab.

1. Experiments and Techniques in Organic Chemistry, D.Pasto, C.Johnson, & M.Miller, Prantice Hall.
2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
3. Hand Book of Organic Analysis, Qualitative & Quantitative, M.T. Clarke, Edward Arnold (Publisher).
4. Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
5. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
6. A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.

SEMESTER – II

CHE – 2.1: INORGANIC AND ANALYTICAL CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

- UNIT - I Metal-Ligand Bonding**
Crystal Field Theory and its limitations, Elementary idea of Angular overlap model, Molecular orbital theory for octahedral, tetrahedral and square planar complexes, σ and π -bonding in molecular orbital theory.
- UNIT – II Electronic Spectra and Magnetic Properties of Transition Metal Complexes.**
Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1 – d^9 states), calculations of Dq , B and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereo-chemical information, anomalous magnetic moments, magnetic exchanges coupling and spin crossover.
- UNIT – III Metal π -Complexes**
Metal Carbonyls, Structure and bonding, Vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls, preparation, bonding, structure and important reactions of transition metal nitrosyls, dinitrogen and dioxygen complexes, tertiary phosphine as ligands.
- UNIT – IV Metal Clusters**
Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.
- UNIT – V Thermal analysis**
Thermo gravimetric analysis (TGA): Instrumentation, derivative therogravimetric analysis (DTG), applications of thermogravimetry. Differential Thermal Analysis (DTA): Instrumentation and applications of differential thermal analysis, simultaneous TG-DTA curves. Thermo gravimetric titration: Principle and applications

Books Recommended:

1. Advanced Inorganic Chemistry, F. A. Cotton, M. Bochmann, C. A. Murillo, G. Wilkinson, 6th Ed., Wiley India (2007).
2. Inorganic Chemistry, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 4th Ed., Pearson Education (2006).
3. Chemistry of the Elements, Greenwood and Earnshaw, Pergamon
4. Inorganic Electronic Spectroscopy, A.B.P.Lever, Elsevier
5. Magnetochemistry, R.L.Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G. Wilkison, R.D.Gillars and J. A. McCleverty, Pergamon
7. Elements of Magneto Chemistry, R. L. Dutta, A. Syamal; 2nd Ed. East West Press Pvt Ltd (2009)
8. Fundamental Concepts of Inorganic Chemistry, Vol. 5; Asim K. Das, CBS Publisher.(2015).
9. Fundamental Concepts of Inorganic Chemistry, Vol. 6; Asim K. Das, CBS Publisher, 2nd Ed (2013).
10. Organometallic Chemistry, R.C. Mehrotra & A. Singh, New Age International, 2nd Ed (2013)
11. Inorganic Chemistry, C. L. Miessler, D. A. Tar, Pearson, 3rd Ed. 2004
12. Analytical chemistry by U N Dash
13. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Hollar. 7th Edition, Harcourt College Publishers, 1996.

CHE – 2.2: ORGANIC CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT - I **Aromatic Electrophilic Substitution**

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, vilsmeier reaction, Gattermann-Koch reaction.

Aromatic Nucleophilic Substitution

The S_{NAr} , S_{N1} , benzyne and S_{RN1} mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The Von Richter, Sommelet-hauser, and Smiles rearrangements.

UNIT - II **Free Radical Reactions.**

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity.

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

UNIT - III **Addition to Carbon-Carbon Multiple Bonds**

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity, Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

Addition to Carbon-Hetero Multiple Bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction.

UNIT - IV **Elimination Reactions**

The E_2 , E_1 and E_{1cB} mechanism and their spectrum. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

Condensation Reactions

Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

UNIT - V **Pericyclic Reactions.**

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward – Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions – conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl systems. Cycloadditions – antarafacial and suprafacial additions, $4n$ and $4n+2$ systems, 2+2 addition of ketenes, 1,3-dipolar cycloadditions and cheletropic reactions.

Sigmatropic rearrangements – suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5-sigmatropic rearrangements. Claisen, Cope and Aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Books Recommended

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley, 6th Ed. (2006).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
3. Pericyclic and organic photochemistry by j. singh and jaya singh, new age international.
4. Pericyclic reactions-by S M Mukharjii, macmillam ind pvt ltd
5. Pericyclic chemistry by Ian fleming, oxford
6. Organic chemistry by John e Mcmurry, 8^{edn} cengage
7. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman. 6th Ed.(1999)
8. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall
9. Modern Organic Reactions, H. O. House, W.A. Benjamin. 2nd Ed.(1972)
10. Principles of Organic Synthesis, R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).
11. Pericyclic Reactions, S. M. Mukherji, Macmillan, India.
12. Modern methods of organic synthesis by carruthers and coldham, 4^e, Cambridge,

CHE – 2.3: PHYSICAL CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT - I **Chemical Dynamics-I**

Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation Activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions, Lindemann reaction.

UNIT - II **Chemical Dynamics-II**

Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen- bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by stopped flow method, relaxation method, flash photolysis and the nuclear magnetic resonance probing the transition state, dynamics of barrier less chemical reactions in solution, Diffusion controlled reaction, dynamics of molecular motion.

UNIT - III **Surface Chemistry**

Adsorption

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, catalytic activity at surfaces estimation of surface area (BET equation), Surface catalysed oxidation of Co to CO₂, surface films on liquids Surface equation of state and its application, Electro-kinetic phenomenon.

Micelles

Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC)/ Kraft temperature, factors affecting the CMC of surfactants, Counter ion binding to micelles, thermodynamics of micellization – phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

UNIT - IV **Electrochemistry-I**

Electrochemistry of solutions. Debye-Huckel–Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Bjerrum model. Solution of strong electrolytes. Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.

Thermodynamics of electrified interface. Derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces, Helmltoz-Perrin, Guoy–Champman, Stern models

UNIT - V **Electrochemistry-II**

Over potentials, exchange current density, derivation of Butler– Volmer equation, Tafel plot. Polarography theory, Ilkovic equation; half wave potential and its significance, Cyclic voltametry. Introduction to corrosion, homogenous theory, forms of corrosion, corrosion monitoring and prevention methods.

Electroanalytical methods

Classification of electroanalytical methods, principles and applications of voltammetry, cyclic voltammetry, anodic stripping voltammetry, polarography, amperometry, coulometry, conductometry and ion selective electrodes (Extensive instrumentations are to be excluded).

Books Recommended

1. Physical Chemistry, P.W. Atkins and J. D. Paulo, Oxford, 2013, 10th edition New Delhi.
2. Physical Chemistry, T. Engel and P. Reid, Pearson, 2006, 1st edition, New Delhi.
3. Physical chemistry of the surfaces, A.W. Adamson and A.P. Gast, John Wiley, 6th edition, 1997, New York.
4. Adsorption and Catalysis, D. K. Chakraborty, 1st edition, 1992, Narosa, New Delhi.
5. Surfactants and Polymers in aqueous solution, Krister Holmberg, Bo Jönsson, Bengt Kronberg and Bjorn Lindman, 2002, John Wiley, Sussex.
6. Surfactants and interfacial phenomena, M.J. Rosen, John Wiley, 2nd edition, New Jersey.
7. Chemical Kinetics, K.J. Laidler, McGraw-Hill.
8. Kinetics and Mechanism of Chemical Transformations, J.Rajaraman and J.Kuriacose, McMillan.
9. Modern Electrochemistry Vol.I and Vol.II. J.O.M.Bockris and A.K.N.Reddy, Plenum, 3rd edition, 1997, London.
10. Fast Reaction – D.N.Hague
11. Chemical Kinetics and Dynamics–2nd Edn. , JISteinfeld, J.S.Francis Co, W.L.Hase , Beutic Hall (1999).
12. Physical Chemistry, G.K. Vemulapalli, Prentice Hall of India Pvt. Ltd., 1993, New Delhi
13. Physical Chemistry, Geoge Woodbury, Brooks/ Cole Publishing, 1997, Pacific Grove, USA
14. Instrumental Methods of Analysis, H.H. Williard. L.L. Merritt and J.A. Dean East-West press,
15. Electrochemical Methods- Fundamentals and Applications, A.J. Baird and L.R. Faulkner, Wiley

CHE – 2.4: SPECTROSCOPY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT - I Nuclear Magnetic Resonance Spectroscopy

Nuclear spin; nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant 'J'. Classification (ABX, AMX, ABC, A₂B₂ etc.), spin decoupling; basic ideas about instrument, NMR studies of nuclei other than proton-¹³C, ¹⁹F and ³¹P. FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.

UNIT - II Electron Spin Resonance Spectroscopy

Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications.

Nuclear Quadrupole Resonance Spectroscopy

Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splittings, Applications.

UNIT - III Vibrational Spectroscopy

Infrared Spectroscopy

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P, Q, R branches. Born-Oppenheimer approximation, Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal-ligand vibrations, normal co-ordinate analysis.

UNIT – IV Raman Spectroscopy

Classical and quantum theories of Raman Effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS)

UNIT - V Spectroscopic methods:

Atomic adsorption spectroscopy: Principle and instrumentation, flame atomization, hollow cathode lamps, application of AAS in qualitative and quantitative analysis.

Flame photometric methods: Basic principle and instrumentation, interference in flame photometry, applications in quantitative analysis.

Nephelometric method: Principle and instrumentation, application in analysis.

Books Recommended

1. Modern Spectroscopy, J. M. Hollas, John Wiley, 4th edition, 2004, Sussex.
1. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Inter science.
2. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood, 1st edition, 1990.
3. Physical Methods in Chemistry, R. S. Drago, Saunders College.
4. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw Hill
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Theory and Applications of UV Spectroscopy, H. H. Jaffe and M. Orchin, IBH-Oxford.

7. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
8. Introduction to Magnetic Resonance, A. Carrington and A. D. Maclachalan, Harper & Row.
9. Inorganic spectroscopic methods, A.K. Brisdon, Oxford University Press, Oxford Chem. Primers, 1997, New York.
10. Spectroscopy, S. Walker and H. Straw, Chapman and Hall Ltd.
11. Energy levels in atom and molecules, W.G. Richards and P.R. Scott, Oxford University Press, Oxford Chemistry Primer vol. 26, 1994, New York.
12. Introduction to Spectroscopy, Pavia, Brooks/Cole Cengage, 4th edition, 2009, Belmont.
13. EPR: Elemental theory and applications, J.A. Well. J.R. Bolton, Wiley, 2nd edition, 2007, New Jersey
14. Electron Paramagnetic resonance of transition ions, A. Abraham and B. Bleaney, Clarendon Press, 1970, Oxford.
15. Essentials of Nuclear Chemistry, H.J. Arnikar, John Wiley, 4th edition, 1995, New Delhi.
16. Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.
17. Symmetry and Spectroscopy of Molecules, K.V. Reddy, New Age International (P) Ltd., 1st edition, 1998, New Delhi.
18. Fundamental Concepts of Inorganic Chemistry, A. K. Das and M. Das, Vol. 7, 1st edition, 2014, CBS Publisher Pvt. Ltd., New Delhi.
19. Molecular Spectroscopy, P.S. Sindhu, Tata McGraw Hill, 1985, New Delhi.

INORGANIC CHEMISTRY

- (a) Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods.
- (b) Preparation of selected inorganic compounds and their study by IR, electronic spectra and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines.
- Synthesis and thermal analysis of group II metal oxalate hydrate (J. Chem. Ed., 1988, 65, 1024).
 - Preparation of Tin (IV) iodide, Tin (IV) iodide, Tin (IV) chloride and Tin(II) iodide. (Inorg. Synth, 1953, 4, 119).
 - Sodium tetrathionate, Na₂S₄O₆.
 - Bromination of Cr (acac)₃ (J. Chem. Edu., 1982, 59,57).
 - Cis and Trans [Co (en)₂Cl₂]₊.
 - Separation of optical isomer of cis-[Co(en)₂Cl₂]Cl. (J. Chem. Soc., 1960, 4369).
 - Determination of Cr (III) complexes.
[Cr(H₂O)₆]NO₃.3H₂O, [Cr(H₂O)₄Cl₂]Cl.2H₂O, [Cr(en)₃]Cl₃, Cr(acac)₃. (Inorg. Synth., 1972, 13,184).
 - Preparation of N, N bis (salicyldehyde) ethylenediamine, salenH₂.
Co(Salen) (J.Chem. Educ., 1977, 54, 443; 1973, 50, 670).
- (a) Determination of O₂ absorption by Co(salen); (Acc. Chem. Res., 1975, 8, 384).
- (b) Reaction of oxygen adduct with CHCl₃ (deoxygenation).
9. Reaction of Cr(III) with a multidentate ligand: a kinetics experiment (Visible spectra Cr-EDTA complex) (J. Am. Chem. Soc., 1953, 75, 5670).
10. Preparation of copper glycine complex-cis and *trans* bis (glycinato Copper (II). (J. Chem. Soc. Dalton, 1979, 1901), (J. Chem. Edu.,1982, 59, 1052).

Spectrophotometric Determinations

- Manganese / Chromium / Vanadium in steel sample
- Iron-phenanthroline complex: Job's Method of continuous variations.
- Copper-Ethylene diamine complex: Slope-ratio method.

Flame Photometric Determinations

- Sodium and potassium when present together

Nephelometric determinations.

- Sulphates

Preparations

Preparation of FOLLOWING compounds and their studies by I.R., electronic spectra, measurements.

- cis*-K[Cr(C₂O₄)₂(H₂O)₂]
- Mn(acac)₃
- K₃[Fe(C₂O₄)₃]
- [Ni(NH₃)₆]Cl₂
- Ni(dm_g)₂

Books Recommended

- Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson, & M. Miller, Prantice Hall.
- Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
- Hand Book of Organic Analysis, Qualitative & Quantitative, M.T. Clarke, Edward Arnold (Publisher).
- Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
- Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
- A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.
- Vogel's Textbook of Quantitative Chemical Analysis; J. Mendhan, R.C. Denney, J.D. Barnes, N. J. K. Thomas; Person, 6th Ed (2007).
- A Text Book of Macro and Semimicro Quantitative Inorganic Analysis; Arthur I. Vogel., Orient Longman, 1st Ed. (1975).

ORGANIC CHEMISTRY

Organic Synthesis

- (a) Preparation of Anthranilic acid
- (b) Preparation of Methyl Orange
- (c) Preparation of Adipic acid by chromic acid oxidation of cyclohexanol.
- (d) *p*-chloro toluene from *p*-toluidine (Sandmeyer reaction)
- (e) Synthesis of *p*-nitroaniline & *p*-bromo aniline (Aromatic electrophilic substitution)
- (f) Synthesis of triphenyl methanol from benzoic acid (Grignard reaction)

Quantitative Analysis

- (a) Estimation of Anilines / Phenols using chromate bromide solution.
- (b) Determination of Iodine and Saponification values of an oil sample.
- (c) Determination of DO, COD & BOD of Water samples.

Books Recommended

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson, & M. Miller, Prantice Hall.
2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
3. Hand Book of Organic Analysis, Qualitative & Quantitative, M. T. Clarke, Edward Arnold (Publisher).
4. Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
5. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
6. A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.

SEMESTER – III
CHE - 3.1: PHOTOCHEMISTRY AND SPECTROSCOPY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT - I Photochemical Reactions

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

Determination of Reaction Mechanism

Classification, rate constants and life times of reactive energy states – determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions – photo-dissociation, gas-phase photolysis.

UNIT - II Photochemistry of alkenes

Intramolecular reactions of the olefinic bond – geometrical isomerism, cyclization reactions, rearrangement of 1,4- and 1,5- dienes.

Photochemistry of Carbonyl Compounds

Intramolecular reactions of carbonyl compounds – saturated, cyclic and acyclic, β,γ -unsaturated and α, β -unsaturated compounds. Cyclohexadienones.

UNIT - III Photochemistry of Aromatic Compounds

Isomerisations, additions and substitutions

Miscellaneous Photochemical Reactions

Photo-Fries reactions of anilides. Photo-Fries rearrangement. Barton reaction. Singlet molecular oxygen reactions. Photochemical formation of smog. Photodegradation of polymers. Photochemistry of vision.

UNIT - IV SPECTROSCOPY

Vibrational Spectroscopy

Normal modes of vibration, Determination of normal modes from Symmetry for AB₂, AB₃, AB₄, AB₅ and AB₆ systems, symmetry of overtones and combination bands, mode of bonding of ambidentate ligands, ethylenediamine and diketonato complexes, application of ir spectra to complexes, Resonance Raman Spectroscopy and its application, particularly for the study of active sites of metallo-proteins myoglobin and haemoglobin

UNIT - V Mossbauer Spectroscopy

Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe⁺² and Fe⁺³ compounds including those of intermediate spin, Sn⁺² and Sn⁺⁴ compounds – nature of M-L bond, coordination number, structure and detection of oxidation state and inequivalent MB atoms.

Book recommended:

1. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wilcy-Eastern.
2. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
3. Introductory Photochemistry, A. Cox and T. Camp. McGraw-Hill.
4. Photochemistry, R. P. Kundall and A. Gibert, Thomson Nelson.
5. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press
6. Physical Methods for Chemistry, R.S.Drago, Saunders Company.
7. Structural Methods in Inorganic Chemistry, E. A. V. Ebsworth, D.W.H.Rankin and S. Cradock, ELBS.
8. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont.
9. 12. EPR: Elemental theory and applications, J.A. Well. J.R. Bolton, Wiley, 2nd edition, 2007, New Jersey.

10. 13. Electron Paramagnetic resonance of transition ions, A. Abraham and B. Bleaney, Clarendon Press, 1970, Oxford
11. Mössbauer Spectroscopy, N.N. Greenwood and T.C. Gibb, , Chapman and Hall 1971, London.
12. Mössbauer Spectroscopy and Transition Metal Chemistry, P. Gülich, R. Link, A. Trautwein, , Springer, 1978, Verlag, Berlin-Heidelberg-New York.
13. Fundamental Concepts of Inorganic Chemistry, A. K. Das and M. Das, Vol. 7,1st edition, 2014, CBS Publisher Pvt. Ltd., New Delhi
14. Atomic Structure and Chemical Bond, Manas Chandra, , 3rd edition, Tata McGraw Hill , 1991, New Delhi

CHE – 3.2: BIOINORGANIC & SUPRAMOLECULAR CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I **Metal Ions in Biological Systems and its Storage Transport and Biomineralization**

Essential trace elements, Ferritin, transferrin, and siderophores.

Calcium in Biology

Transported regulation, Intracellular Ca^{2+} transport, Ca^{2+} ATPase, $\text{Na}^+ / \text{Ca}^{2+}$ exchange, mitochondrial influx and efflux. Inositol triphosphate, Ca^{2+} regulated intracellular processes: Calmodulin, Troponin C,

UNIT-II **Metalloenzymes**

Iron enzymes – catalase peroxidase and cytochromes, Cyt-P450 Copper enzymes- Superoxide dismutase Molybdenum oxatransferase.

Enzymes – xanthine oxidase. Coenzyme vitamin B₁₂. Sulphur proteins.

UNIT III **Nitrogen fixation**

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Photosynthesis

Chlorophylls, photo system I and photo system II in cleavage of water

UNIT-IV **Transport and Storage of Dioxygen**

Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerthrin, model synthetic complexes of iron, cobalt and copper

UNIT V **Supramolecular Chemistry.**

Concepts and language.

(A) Molecular recognition : Molecular receptors for different types of molecules including arisonic substantes, design and synthesis of coreceptor molecules and multiple recognition.

(B) Supramolecular reactivity and catalysis.

(C) Transport processes and carrier design.

(D) Supramolecular devices, Supramolecular photochemistry, supramolecular electronic, ionic and switching devices.

Some example of self-assembly in supramolecular chemistry.

Books Recommended

1. Principles of Bioinorganic Chemistry, S .J. Lippard and J. M. Berg., University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valenting, University Science Books.
3. Inorganic Biochemistry vols I and II ed. G. L.Eichhom, Elsevier
4. Progress in Inorganic Chemistry, Vols 18 and 38 ed J. J. Lippard, Wiley
5. Bioinorganic Chemistry, Asim K. Das, Books and Allied, 2nd Ed (2007).
6. Supramolecular Chemistry, J. W. Steed and J. L. Atwood, Willey, 2nd Ed (2009).
7. Bioorganic, Bioinorganic and Supramolecular Chemistry, P.S. Kalsi, J.P. Kalsi, New Age International, 2nd Ed (2012).
8. An Introduction of Supramolecular Chemistry, Asim K. Das, Books and Allied, 1st Ed

CHE – 3.3: BIOORGANIC CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I Introduction

Basic considerations Proximity effects and molecular adaptation.

Enzymes-I

Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification.

UNIT-II Enzymes-II

Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis,

UNIT - III Mechanism of Enzyme Action

Kinetics of enzyme action, Michealis Menten and Lineweaver-Burk plots, reversible and irreversible inhibition. Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanism for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

UNIT - IV Reactions Catalyzed by Enzymes and Co-Enzyme Chemistry-I

Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP Cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerization reactions, β -cleavage and condensation, some isomerization and rearrangement reactions.

UNIT –V Reactions Catalyzed by Enzymes and Co-Enzyme Chemistry-II

Enzyme catalyzed carboxylation and decarboxylation. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme. A, thiamine pyrophosphate, pyridoxal phosphate, NAD^+ , NADP^+ , FMN, FAD, lipoic acid, vitamin B₁₂ Mechanisms of reactions catalyzed by the above cofactors.

Books Recommended

1. Bioorganic Chemistry, A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
3. Enzyme Chemistry: Impact and Applications, Ed. Collin J. Suckling, Chapman and Hall.
4. Enzyme Mechanisms Ed, M. I. Page and A. Williams, Royal Society of Chemistry.
5. Fundamentals of Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
6. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
7. Enzymatic Reaction Mechanisms C. Walsh, W. H. Freeman.
8. Enzyme Structure and Mechanism, A Fersht. W.H. Freeman.
9. Biochemistry: The Chemical Reactions of Living Cells, D.F. Metzler, Academic Press.

CHE – 3.4: ENVIRONMENTAL CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT - I **Environment**

Introduction Composition of atmosphere, vertical temperature, heat budget of the earth atmospheric system, vertical stability atmosphere. Biogeochemical Cycles of C,N,P,S and O. Biodistribution of elements.

Hydrosphere

Chemical composition of water bodies-lakes, streams, rivers and wet lands etc. Hydrological cycle.

Aquatic pollution-inorganic, organic, pesticide, agricultural, industrial and sewage, detergents, oil spills and oil pollutants.

UNIT – II **Water quality parameters-**

Dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulphate, phosphate, nitrate and micro-organisms. Water quality standards

Analytical methods for measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg, Pb, Se etc.) residual chloride and chlorine demand.

Purification and treatment of water.

UNIT – III **Soils**

Composition, micro and macro nutrients, Pollution –fertilizers, pesticides, plastics and metals. Waste treatment.

Atmosphere

Chemical composition of atmosphere-particles, ions and radicals and their formation.

Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluorophydrocarbons.

Green house effect, acid rain, air pollution controls and their chemistry. Analytical methods for measuring air pollutants. Continuous monitoring instruments.

UNIT – IV **Industrial Pollution**

Cement, Sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers, drugs etc. Radionuclide analysis. Disposal of wastes and their management.

UNIT – V **Environmental Toxicology**

Chemical solutions to environmental problems, biodegradability, principles of decomposition better

Books Recommended

1. Environmental Chemistry , S.E. Manahan, Lewis Publishers
2. Environmental Chemistry, A.K. De, Wiley Eastern.
3. Environmental Chemistry with Green Chemistry, A. K. Das, Books & Allied (P) Ltd., Kolkata, 1st Edn, 2010.
4. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication, Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
5. Environmental Chemistry, C. Baird, W.H. Freeman
6. Hand Book of Environmental Analysis, Pradyot Patnaik, Lewis Publishers (1997)
7. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, Washington D.C. 2005, USA, 17th Edition (1998).

ANALYTICAL CHEMISTRY

1. Verification of Beer-Lambert's Law by colorimetry.
2. Determination of Na^+ / K^+ ions by flame photometry.
3. Determination of ascorbic acid in vitamin C tablets.
4. Determination of Dissolved Oxygen (DO) in water samples.
5. Measurement of pH of soils by a pH meter.
6. Determination of Chemical Oxygen Demand (COD) in water samples.
7. Determination of moisture content in soils by gravimetric method.
8. Analysis of fat in a butter sample.
9. Determination of Biochemical Oxygen Demand (BOD) in water samples.
10. Estimation of metal ions by ion-exchange method.

Books Recommended.

1. Vogel's Text Book of Quantitative Chemical Analysis By J.Mendham, R. C.Denney, J. D.Barnes, M. J .K. Thomas, Pearson Education Publishers, 6th Edition (2007).
2. Hand book of Environmental analysis by Pradyot Patnaik, Lewis Publishers, USA (1997).
3. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, Washington, DC, USA, 17th

PHYSICAL CHEMISTRY**Error Analysis and Statistical Data Analysis**

Errors, types of errors, minimization of errors, error distribution curves, precision, accuracy and combination; statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F & Q test; linear regression analysis, curve fitting. Calibration of volumetric apparatus, burette, pipette and standard flask.

Adsorption

To study surface tension – concentration relationship for solutions (Gibbs equation)

Chemical Kinetics

- (i) Determination of the effect of (a) Change of temperature (b) Change of concentration of reactants and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester / ionic reactions.
- (ii) Determination of the velocity constant of hydrolysis of an ester / ionic reaction in micellar media.
- (iii) Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.

Solutions

- (i) Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behavior that occurs with a strong electrolyte.

Electrochemistry

Conductometry

- (i) Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.
- (ii) Determination of solubility and solubility product of sparingly soluble (e.g., PbSO_4 , BaSO_4) conductometrically.
- (iii) Determination of the strength of strong and weak acids in a given mixture conductometrically.
- (iv) Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.

A. Potentiometry / pH metry.

- (i) Determination of strengths of halides in a mixture potentiometrically.
- (ii) Determination of the valency of mercurous ions potentiometrically.
- (iii) Determination of the strength of strong and weak acids in a given mixture using a potentiometer / pH meter.
- (iv) Acid-base titration in a non-aqueous media using a pH meter.
- (v) Determination of the dissociation constant of acetic acid in acetone by titrating it with KOH in what medium.
- (vi) Determine the $\text{PK}'\text{s}$ of a dibasic acid by pH titration using a pH meter.

Polarimetry

- (i) Determination of rate constant for hydrolysis / inversion of sugar using a polarimeter.
- (ii) Enzyme kinetics – inversion of sucrose.

Books Recommended

1. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
2. Findley's Practical Physical Chemistry, B.P.Levitt, Longman.
3. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill, 1983, New Delhi.

SEMESTER – IV

CH E – 4.1: ORGANIC SYNTHESIS

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I **Disconnection Approach**

An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis.

Oxidation

Introduction. Different oxidative processes.

Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated and unactivated). Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids. Amines, hydrazines, and sulfides. Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium(III)nitrate.

Reduction

Introduction. Different reductive processes.

Hydrocarbons – alkanes, alkenes, alkynes and aromatic rings.

Carbonyl compounds – aldehydes, ketones, acids and their derivatives. Epoxides.

Nitro, nitroso, azo and oxime groups.

Hydrogenolysis.

UNIT II **Protecting Groups**

Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

One Group C-C Disconnection

Alcohols and carbonyl compounds, regioselectivity, Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

Two Group C-C Disconnections

Diels-Alder reaction, 1,3-difunctionalised compounds, α,β - unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Michael addition and Robinson annulation.

UNIT III **Ring Synthesis**

Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis.

Synthesis of some Complex Molecules

Application of the above in the synthesis of following compounds. Camphor, Longifolene, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A

UNIT IV **Alkyl and Aryls of Transition Metals**

Types, routes of synthesis, stability and decomposition pathways organo-copper in organic synthesis

Compounds of Transition Metal-Carbon Multiple Bonds

Alkylidenes, Alkylidynes, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis

UNIT-V **Homogenous Catalytic Synthesis of Organic Chemicals by Transition Metal Complexes**

Coordinative unsaturation, Oxidative Addition Reactions, Reductive elimination reaction. Insertion reactions (insertion of CO, SO₂ and alkenes). Reactions of coordinated carbon monoxide in metal carbonyls. Homogenous hydrogenation of alkenes, hydrobromylation of alkenes, Zeigler Natta Polymerization of ethylene, reduction of carbon monoxide by hydrogen (Fischer-Tropsch reaction)

Books Recommended

1. Designing Organic Synthesis, A programmed introduction to synthon approach, S. Warren, Wiley.
2. Organic chemistry by clayden et al, 2nd edn oup
3. Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, VCH, Weinheim, Germany.
4. Some Modern Methods of Organic synthesis. W. Carruthers, Cambridge Univ. Press.
5. Modern Synthetic Reactions, H. O. House, W.A. Benjamin
6. Advanced Organic Chemistry: Reactions, Mechanisms and Streucture, J. March, 7edn Wiley.
7. Principles of Organic synthesis, R. Norman and J. M. Coxon, Blackie Academic & Professional.
8. Advanced Organic Chemistry Part B, F. A. Carey and R. J. Sundberg, Plenum Press.
9. Organic Chemistry: The disconnection approach, S. Warren, John Wiley and Sons.
10. Principles and Application of Organotransition Metal Chemistry, J. P. Collman, L.S. Hegedus, J.R. Norton and R.G. Finke, University Science Books.
11. Basic organometallic chemistry by B D Gupta, Anil J Elias, university press
12. Metallo-organic Chemistry, A.J. Pearson, Wiley
13. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, 4th Ed, Willey (2005).
14. Fundamental Concepts of Inorganic Chemistry, Vol. 6; Asim K. Das, CBS Publisher, 2nd Ed (2013).
15. Organometallic Chemistry, R.C. Mehrotra & A. Singh, New Age International, 2nd Ed (2013).
16. Organic synthesis using transition metals by Bellar and Bohm, wiley-vch.

CHE – 4.2: POLYMER CHEMISTRY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I Basics

Importance of Polymers; Basic concepts: Monomers, repeat units, degree of polymerization, Linear, branched and network polymers. Classification of Polymers. Polymerization: condensation, addition, radical chain, ionic, coordination and co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

UNIT-II Polymer Characterization

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weights. End-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers-chemical analysis of polymers, spectroscopic methods, X-ray diffraction study, Microscopy. Thermal analysis and physical testing-tensile strength. Fatigue, impact. Tear resistance. Hardness and abrasion resistance.

UNIT III Structure and Properties

Morphology and order in crystalline polymers-configurations of polymer chains. Crystal structures of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point. T_m -melting points of homogeneous services, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, T_g -Relationship between T_m and T_g , effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

UNIT IV Polymer Processing

Plastics, elastomers and fibres. Compounding. Processing techniques: Calendering, die casting, rotational castin, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

UNIT V Properties of Commercial Polymers

Polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers – Fire retarding polymers and electrically conducting polymers. Biomedical polymers – contact lens, dental polymers, artificial heart kidney, skin and blood cells.

Books Recommended

1. Text book of Polymer Science, F.W. Billmeyer, Jr. Wiley.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R.M. Otanbrite.
4. Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.
5. P.J. Flory, 'Principles of Polymer Chemistry', Cornell Press, (Recent Edition
6. 'Principles of Polymer Systems', M. Elpaw Hill Book Company, 2nd Edn., 1982.
7. K. J. Saunders, , 'Organic Polymer Chemistry', Chapman & Hall, London, 1973.

CHE – 4.3: Solid state chemistry

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I Solid State Reactions

General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

Crystal Defects and Non-Stoichiometry

Perfect and imperfect crystals, intrinsic and extrinsic defects—point defects, line and plane defects, vacancies—Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centers, non-stoichiometry and defects.

UNIT-II Electronic Properties of solids

Metals, insulators and semiconductors, electronic structure of solids- Band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.

Optical properties of solids

Optical reflectance, photoconduction, photoelectric effects, refraction, dispersion, polarization

UNIT-III Magnetic Properties of Solids

Classification of materials. Quantum theory of paramagnetism – cooperative phenomena – magnetic domains, hysteresis.

Organic Solids

Electrically conducting solids, organic charge transfer complex, organic metals, new superconductors.

UNIT IV Diffraction Methods

X-ray Diffraction

Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, indexing, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices, and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, Ramchandran diagram.

UNIT-V Neutron Diffraction

Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell.

Books Recommended

1. Solid State Chemistry and its Applications, A.R. West, Wiley, 1989, 2nd edition, Singapore.
2. Basic solid state chemistry by A.R West, wiley
3. Principles of the Solid State, H.V. Keer, Wiley Eastern. Limited, 1993, New Delhi,.
4. Solid State Chemistry, N.b.Hannay.
5. New direction in solid state chemistry by C N R RAO
6. Solid State Chemistry, D.K. Chakrabarty, New Age International Limited, 1996, New Delhi
7. Understanding solids, The Science of Materials, R. J. Tilley, John Wiley & Sons, 2004, Sussex.
8. Solid state Physics, N.W. Ashcroft and N. Mermin, Harcourt College Press, 1976, Florida.
9. Solid state Physics, J.P. Srivastava, Phi Learning Pvt. Ltd, 2011.
10. Applications of Neutron Powder diffraction, E.H. Kisi and C.J. Howard, Oxford Science, 2008, New York.
11. Introduction to Solid State Physics, C. Kittel, John Wiley, 1976, New York .
12. Elements Of X Ray Diffraction, B. D Cullity, Addison-Wesley Publishing Company Inc., 1956 , USA.

CHE – 4.4: APPLICATIONS OF SPECTROSCOPY

Mid-sem=30, End-sem=70

Time – 3 hours

FM-100

UNIT I Ultraviolet and Visible Spectroscopy

Various electronic transitions (185–800 nm), Beer–Lambert Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls.

UNIT-II Infrared Spectroscopy

Instrumentation and sample handling, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds) Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance, FTIR. IR of gaseous, solids and polymeric materials.

Optical Rotatory Dispersion (ORD) and Circular Dichroism(CD).

Defination, deduction of absolute configuration, octant rule for ketones.

UNIT III I.Nuclear Magnetic Resonance Spectroscopy

Chemical shift values and correlation for protons bonded to carbon (Aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two,three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Resonance of other nuclei-F,P.

UNIT IV Carbon-13 NMR Spectroscopy

General considerations, chemical shift (Aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two dimension NMR spectroscopy – COSY, NOESY, DEPT, INEPT, APT and INDEQUATE techniques.

Electron Spin Resonance Spectroscopy

Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as $\text{PH}_4\cdot$, $\text{F}_2\cdot$ and $[\text{BH}_3]\cdot$.

UNIT-V Mass Spectrometry

Introduction, ion production – EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Books Recommended

1. Spectroscopy of Organic compounds ^{6th} Ed., P. S. Kalsi, New Age International (P) Ltd. Pub.
2. Organic Spectroscopy, W. Kemp, Palgrave
3. Organic spectroscopy by jaga mohan, narosa
4. Organic spectroscopy by L D S YADAB
5. Spectroscopy by H KAUR,PRAGATI
6. Organic Spectroscopy By Gurdeep Raj Chatwal, Krishana Prakashan
7. Instrumental Analysis By G. R. Chatwal, Krishana Prakashan

8. A Complete Introduction to Modern NMR Spectroscopy, Roger S. Macomber, Willey Publication,
9. Modern NMR Spectroscopy: A Guide for Chemists. J. K. M. Sanders, B. K. Hunter. Oxford University Press, 1993
10. Principles of nuclear magnetic resonance in one and two dimensions. R. R. Ernst, Geoffrey Bodenhausen, and Alexander Wokaun. Oxford University Press, 1987
11. Spectrometric Identification of Organic Compounds, R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, Willey, 8th Edition (2015)
12. Fundamental concept of inorganic chemistry by Asim k das vol-7,CBS DISTRIBUTERS
13. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont
14. EPR: Elemental theory and applications, J.A. Well. J.R. Bolton, Wiley, 2nd edition, 2007
15. Electron Paramagnetic resonance of transition ions, A. Abraham and B. Bleaney, Clarendon Press, 1970, Oxford

PHYSICAL CHEMISTRY**1. Thermodynamics**

- (i) Determination of partial molar volume of solute (e.g., KCl) and solvent in a binary mixture.
- (ii) Determination of the temperature dependence of the solubility of a compound in two solvents having similar intermolecular interactions (benzoic acid in water and in DMSO-water mixture) and calculate the partial molar heat of solution.

2. Spectroscopy

- (i) Determination of pK_a of an indicator (e.g., methyl red) in (a) aqueous and (b) micellar media.
- (ii) Determination of stoichiometry and stability constant of inorganic (e.g. ferric-salicylic acid) and organic (e.g. amine-iodine) complexes.

3. Polarography

- (i) Estimation of Pb²⁺ and Cd²⁺ / Zn⁺ and Ni²⁺ ions in a mixture of Pb²⁺ and Cd²⁺ / Zn²⁺ and Ni²⁺ by polarography.
- (ii) Determination of dissolved oxygen in aqueous solution of organic solvents.

4. Electronics

This lab course will have theory as well as practicals and the lectures shall be delivered during lab hours.

5. Basic Electronics

Notations used in an electric circuit, study of electronic components and colour codes, conversion of chemical quantities into electrical quantities. Transducer, illustration with electrodes, thermocouples and thermistors.

6. Active Components

Introduction to ordinary diodes and Zener diodes with some emphasis on p-n junction as a solid state property. Use of diodes as rectifiers, clipping and clamping circuits. Power supplies.

Books Recommended

1. Experimental Physical Chemistry, B.P. Levitt, Longman.
2. Findlay's Practical Physical Chemistry, revised B.P. Levitt, Longman.
3. Experiments in Physical Chemistry, J.C. Ghosh, Bharati Bhavan.
4. Experimental Physical Chemistry, R.C. Behera and B. Behera, Tata McGraw Hill, 1983. New Delhi.

POLYMER CHEMISTRY

1. Synthesis of Polymethyl methacrylate by emulsion polymerization.
2. Determination of viscosity average molecular weight of Polystyrene in benzene and toluene.
3. Kinetics of addition polymerization of methyl methacrylate using benzoyl peroxide as initiator.
4. Synthesis of polyethylene tetrasulphide by emulsion polymerization.
5. Determination of chain length of Polyacrylonitrile using Mark-Houwink equation.
6. Kinetics of polymerization of acrylonitrile using Ce(IV)-cyclohexanol redox system.
7. Determination of Viscosity average molecular mass of Polyacrylonitrile in DMF.

Books Recommended

1. Polymer Science & Technology, Tata Mcgraw-Hill.
2. Organic Chemistry of Synthetic High Polymers, R.W. Lenz.
3. Introduction to Physical Polymer Science, L.H. Sperling, 4th ed. John Wiley & Sons (2005)
4. Polymer Chemistry: An Introduction, 3rd ed., Malcolm P. Stevens, Oxford University Press (2005)
5. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).
6. Contemporary Polymer Chemistry, 3rd ed. Harry R. Allcock, Frederick W. Lampe and James E. Mark, Prentice-Hall (2003)
7. Textbook of Polymer Science, 3rd ed. Fred W. Billmeyer, Wiley-Interscience (1984)
8. Polymer Science and Technology, 2nd ed. Joel R. Fried, Prentice-Hall (2003)
9. Introduction to Macromolecular Science, 2nd ed. Petr Munk and Tejraj M. Aminabhavi, John Wiley & Sons (2002)
10. Practical Polymer Analysis, T.R Crompton, Springer Publication, (1993)