

VEER NARMAD SOUTH GUJARAT UNIVERSITY
M.Sc.-I (CHEMISTRY)
TO COME IN FORCE FROM JUNE-2008
PAPER-I (INORGANIC CHEMISTRY)

Max. Marks:52

Total Periods: 90

SECTION-I

UNIT-I : QUANTUM CHEMISTRY: (15 Periods)

Operators:

- Definitions
- Operator algebra
- Linear operator
- Hamiltonian operator
- Hermitian operators
- Eigen value relation, and
- Some important theorems

Mechanics:

Angular momentum, Angular momentum operators, Commutation relationship, Eigen values and eigen functions of angular momentum, Shift operators, electron spin, coupling of angular momentum,

Simple harmonic oscillator (where the potential energy is not constant)

- One dimensional harmonic oscillator
- Normalisation and the characteristic of the eigen functions of a harmonic oscillator.
- The selection rule for the harmonic oscillator.
- The two particle rigid rotator.
- Moment of inertia, Derivation of kinetic energy of relation, Selection rule.

Reference Books:

1. Quantum Chemistry by Ira N. Levine, Prentice-Hall of India Pvt. Ltd., New Delhi, 1994.
2. Introductory Quantum Chemistry (Third edition) by A. K. Chandra Tata McGraw Hill Pub. Co. Ltd., New Delhi, 1988.
3. Quantum Mechanics in Chemistry (3rd edition) by N. W. Hanna, Benjamin, Menlo Park, Calif, 1981.
4. Problems in Quantum Chemistry and Physics by C. S. Johnson and L. G. Pedersen, Addison-Wesley, Reading, Mass., 1974.
5. Problems in Quantum Chemistry by P. Jorgensen and J. Oddershede Addison-Wesley, Reading, Mass., 1983.
6. Quantum Chemistry and Spectroscopy by M. S. Pathania, Vishal Publications, India, 1981.

UNIT-II : SYMMETRY AND GROUP THEORY IN CHEMISTRY AND ITS APPLICATIONS: (15 Periods)

Representation of groups:

- Preparation of matrices and vectors.
- Matrix notations for geometrical transformations.
- Orthogonality theorem and its consequences.
- Reducible and irreducible representations and their relation.
- Preparation of character table for C_{2v} , D_{2h} , C_{3v} and D_{3h} point groups.

Application of group theory to -

- Transformation properties of atomic crystals.
- Hybridisation scheme for σ and π -bonding.
- Spectroscopy.

Reference Books:

1. Chemical applications of group theory by F. A. Cotton (Second edition), Wiley Eastern Limited, 1976, New Delhi.
2. Group theory and its applications by P. K. Bhattacharya, Himalaya Publishing House, Mumbai, 1986.
3. Group theory and symmetry in Chemistry by L. R. Hall, McGraw Hill, New York, 1989.
4. Quantum Chemistry by I.N. Levine (4th edition), Prentice-Hall, New Delhi, 1994.
5. Introductory Quantum Chemistry by A. K. Chandra (4th edition), Tata McGraw Hill Pub. Co. Ltd., New Delhi.

UNIT-III : The reaction rates and mechanism of Inorganic reactions (15 Periods) of transition metal complexes (Inorganic Reaction Mechanism):

(a) Introduction (What is kinetics?):

Labile and inert complexes, factors responsible for lability and inertness of complexes.

(b) Experimental Techniques:

(i) Direct chemical analysis, (ii) Photometry, (iii) Electrometry, (iv) Polarimetry, (v) Isotopic tracer, and (vi) Fast reaction techniques.

Fast reaction techniques:

- (a) The constant flow method
- (b) The stopped flow method
- (c) The quenched flow method
- (d) Electrochemical techniques
- (e) Nuclear and paramagnetic resonance
- (f) Relaxation techniques.

(c) The interpretation of rate data:

- (i) Reaction order and rate constants
- (ii) The effect of temperature
- (iii) The effect of ionic strength
- (iv) Isotopic labeling

(d) Solvolytic reaction:

- (i) Importance of the solvent
- (ii) Isotopic exchange between complex and the solvent
- (iii) The hydrolysis of complexes

(e) Substitution reactions:

- (i) Kinetic features of substitution reactions
- (ii) Rates of non-isotopic ligand replacement

(A) Four coordinated complexes (Pt^{+2} , Pd^{+2} complexes)
Trans effect, Trans effect theories.

(B) Six coordinated complexes (Co^{+3} and Cr^{+3} complexes)

(f) Oxidation-Reduction processes.

Reference Books:

1. 'Kinetics and Mechanism' by A. A. Frost and R. G. Pearson, Wiley, New York, 1953, 1961.
2. Mechanism of Inorganic Reactions by F. Basolo and R. G. Pearson, Second Edition, Wiley Eastern Limited, New Delhi, 1977.
3. Advanced Inorganic Chemistry and Radiochemistry, H. Taube, 1, 2 (1959), Review article. Inorganic Reaction Mechanism by S. G. Skyes.

SECTION-II

UNIT-IV : MAGNETIC PROPERTIES AND ELECTRONIC SPECTRA OF TRANSITION METAL COMPLEXES: (15 Periods)

- (I) Introduction:
 - (i) Definitions of magnetic properties
 - (ii) Types of magnetic bodies
 - (iii) The source of paramagnetism
 - (iv) Diamagnetism and Pascal's constant
- (II) The Elementary theory of magnetochemistry.
- (III) Properties of paramagnetic bodies:
 - (i) Thermal energy and magnetic property
 - (ii) Magnetic moments of different multiplet width
- (IV) Experimental:
 - (i) Determination of magnetic susceptibility: (a) Gouy method, and (b) Faraday method.
 - (ii) Magnetic anisotropy.
- (V) Magnetic properties based on crystal field model.
- (VI) Numerical Problems on Magnetic Property.
- (VII) Magnetic moment - (i) intrinsic orbital contribution, (ii) Spin orbit coupling, and (iii) Temperature independent paramagnetism (T.I.P.). Anomalous magnetic moments, magnetic exchange coupling and spin cross over.
- (VIII) Antiferromagnetism and Ferromagnetism:
 - (i) Types of antiferromagnetic interaction.
 - (ii) Antiferromagnetic exchange pathways.

Reference Books:

1. Magnetochemistry by R. L. Carlin.
2. Introduction to Magnetochemistry by A. Carnshaw, Academic Press, London.
3. Magnetism and Transition Metal Complexes by F. E. Mabb and D. J. Machin, Chapman and Hall, London.
4. Advanced Inorganic Chemistry by F. A. Cotton and R. G. Wilkinson, John Wiley & Sons, N.Y.
5. Elements of Magnetochemistry by A. Syamal and R. L. Dutta, Affiliated East-West Press, New Delhi, 1993.

UNIT-V : METAL π -COMPLEXES:**(15 Periods)**

Metal carbonyls, structure and bonding, vibrational spectra of metal for bonding and structural elucidation, important reactions of metal carbonyls.

Bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes;(Two Compounds VIZ) tertiary phosphine as ligand.

UNIT-VI : INORGANIC POLYMERS:**(15 Periods)**

- (1) Introduction:
 - Definition of polymers and their depiction.
 - Types of characteristic of inorganic polymers.
- (2) Characterization of inorganic polymers (Physical properties)
 - By molecular weights
 - number average
 - weight average
 - Experimental techniques determination of molecules weight of polymers by
 - a chemical method
 - light scattering
 - Uses of molecular weights
 - Molecular weight distribution
 - Structural features of polymers
 - backbone bonding
 - branching and cross-linking
 - chemical and stereochemical variability
 - Crystallinity
 - importance and requirements
 - Methods for determining percent crystallinity
 - Dilatometry, crystallography, spectroscopy and colorimetry, some additional information from X-ray diffraction.

Transition: (Property w.r. to temperature)

- Definitions
- Illustrative representations
- Dilatometric results
- Calorimetric results
 - Bomb calorimetry
 - DTA
 - DSC

Mechanical properties

- Elasticity
- Viscosity
- Viscoelasticity

Classification, types of inorganic polymers, synthesis, properties, structures and uses in following polymers:

- (i) Polyphosphazenes
- (ii) polysiloxanes

Reference Books:

- (1) Inorganic Polymers by James E. Mark, H. R. Allcock and Robert West, Prentice Hall of India Pvt. Ltd., New Delhi, 1992.
- (2) Text-book of Polymer Science, 2nd edition, by F. W. Jr. Billmeyer Jr., Wiley-Interscience, New York, 1971.
- (3) Inorganic and Organometallic Polymers by M. Zelding, K. J. Wynne and H. R. Allcock, ACS Symposium Series, American Chemical Society, Washington, DC, Vol. 360 (1988).
- (4) Introductory Polymer Chemistry by G. S. Misra, Wiley Eastern Ltd., 1993.
- (5) Phosphorous-Nitrogen Compounds, H. R. Allcock, Academic, New York, 1972.
- (6) In Encyclopaedia of Polymer Science and Engineering, 2nd edn., by R. Baney and G. Chandra, Wiley-Interscience, New York, 1987.

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SECTION-I

UNIT-I : REACTION MECHANISM & REACTIVE INTERMEDIATES:

(15 Periods)

Detailed study of organic reaction intermediates. Generation, structure, stability and reactions of –

(i) Carbocations (Classical and non-classical):

Phenonium ion, norbornyl system, common carbocation rearrangements. Application of NMR spectroscopy in detection of carbocations.

(ii) Carbanions:

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

(iii) Carbenes:

Mechanism of Arndt-Eistert reaction, Wolff rearrangement, Reimer-Tiemann reaction and Bamford Steven's rearrangement - Shapiro reaction.

(iv) Free Radicals:

Types of free radical reactions, free radical substitution mechanism, mechanism at aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at bridge-head.

Reactivity in attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkenes and arylation of aromatic compounds by diazonium salts. Sandmeyer reactions. Free radical rearrangements, Hunsdiecker reaction.

(v) Nitrenes:

Mechanism of Hofmann, Curtius, Losson and Schmidt rearrangement.

(vi) Arynes:

Methods of generation, Reactions and structure.

Recommended Books:

1. Comprehensive Organic Chemistry by Barton and Ollis (Eds.) (Pergamon Press, 1979), Volume 1 : Chapters 2, 7 and 2.8, Volume 2, Chapter 6.6).
2. Reaction Mechanism and Reagents in Organic Chemistry by C. R. Chatwal (Himalaya Publishing House, Bombay, 1987).
3. Organic Chemistry Reactions and Reagents by O. P. Agrawal (Goel Publishing House, Meerut, 1986).
4. The Chemistry of Free Radicals by R. L. Hudang, S. H. Goh and S. H. Ong (Edward Arnold, 1974).
5. Principles of Ionic Organic Reagents by E. R. Alexander (John Wiley & Sons, Inc.).
6. Carbenes, Benzynes and Nitrenes by Gilchrist, T. L. and Rees.
7. Advance Organic Chemistry by Jerry March Principles.

UNIT-II : GREEN CHEMISTRY AND PHOTOCHEMISTRY**(15 Periods)****(A) BASIC PRINCIPAL OF GREEN CHEMISTRY****TWELVE PRINCIPLES:**

Prevention of Waste / By – products, Maximum incorporation of the reactants into the final products, Prevention or minimization of hazardous products, Designing safer chemicals, Energy requirements for synthesis, Selection of starting materials, Use of protecting groups, Use of catalyst, products designed should be biodegradable, Designing of manufacturing plants, Strengthening of analytical techniques.

1. New Trends in Green Chemistry, 2nd edition, V.K.Ahluwalia and M. Kidwai, Anamaya Publisheres, New Delhi.
2. Green Chemistry, Theory and Practice, Pual T. Anastas and John C. Warner, Oxford University Press, 2000, New York, USA.
3. Green Chemistry : An Introductory Text, Mike Lancaster, Green Chemistry Network, University of York, RSC, 2002.
4. Handbook of Hreen Chemistry and Technology, edited by: james Clark and Duncan Macquarrie, Blackwell publishing.

(B) ORGANIC PHOTOCHEMISTRY:**(i) Photochemical Reactions:**

Photochemical energy, Electronic excitation and molecular, Orbital view of excitation, Fluorescence, Phosphorescence and Chemiluminescence. Excited states and modes of dissipation of energy. Energy transfer, quantum efficiency.

(ii) Photochemistry of Carbonyl Compounds:

Reactivity of electronically excited ketones. Representation of excited states of ketones, Photo reduction. Norrish Type I & II reactions. Reactions of cyclic ketones, Oxetane formation (Paterno-Buchi reaction).

Recommended Books:

1. Reaction Mechanism in Organic Chemistry by S. M. Mukherji and S. P. Singh (McMillan India Ltd., 1976).
2. Molecular Reactions and Photochemistry by Charles H. Depuy and Orville L. Chapman (Prentice Hall of India Pvt. Ltd., 1975).
3. Fundamentals of Photochemistry by K. K. Rohatgi-Mukherjee (Eastern Limited, New Delhi-110 002, 1978).
4. Organic Chemistry (3/e) by J. B. Hendrickson, Donald J. Crem and George S. Rammond (McGraw-Hill Book Co. & Kogekusha Co. Ltd., 1970).

UNIT-III :**(15 Periods)****(A) CARBOHYDRATES:**

Structural determination of starch and cellulose, their conformations
Carbohydrate metabolism - Kreb's cycle, glycolysis, glycogenesis and glycogenolysis, glyconeogenesis,

(B) NUCLEIC ACID:

Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Chemical and enzymatic hydrolysis of nucleic acids, structure of nucleosides, nucleotides, chemical synthesis of nucleosides. Structure of Ribonucleic acid (RNA) and deoxyribonucleic acid (DNA). The chemical basis for heredity, an overview of replication of DNA, transcription, translation and genetic code - Chemical synthesis of ADP, ATP.

Recommended Books:

1. Organic Chemistry by Finar, I. L., Vol. II (5/e) (London, ELBS).
2. Organic Chemistry (5/e) by Morrison & Boyd (Prentice Hall).
3. The Carbohydrates by S.F. Dyke, Volume V in the series, 'The Chemistry of Natural Products', edited by K. W. Bentley (Interscience Publishers).
4. An Introduction to the Chemistry of Carbohydrates by Guthrie and Honeyman [Clarendon Press, 1964, (2/e)].
5. A guide to IUPAC nomenclature of Organic Compounds, R. Fanico, W. R. Powell and Jean-Claude Richard, Jain Interscience Press, New Delhi.

SECTION-II**UNIT-IV :****(15 Periods)****(A) ORGANOMETALLIC COMPOUNDS:**

Carbon-metal bonds in organometallic compounds, organometallic nomenclature, Preparations of organolithium, Organocopper and lithium diorganocuprate and their synthetic applications.

Preparation of organoboranes, stereochemistry of hydroboration, mechanism of hydroboration - oxidation, synthetic uses of organozinc compounds.

Addition to Carbon-Hetero multiple bonds:

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles.

Recommended Books:

1. Organic Chemistry by Francis A. Carey (McGraw-Hill Book Co., 1987).
 2. Principles of Organic Chemistry by R.C.C. Norman (Chapman and Hall, 1986).
 3. Organometallic Chemistry by P. L. Pauson (Edward Arnold, 1968).
 4. Principles of Organometallic Chemistry by Coats, Green, Powell & Wade (Chapman and Hall, 1977).
 5. Guide Book to Organic Synthesis by R. K. Mackie & D. M. Smith (Longman, 1983).
 6. Organic Synthesis via Poranos by H. C. Brown (John Wiley & Sons, New York, 1975).
- (B) EMERGING GREENER TECHNOLOGIES AND ALTERNATIVE ENERGY SOURCES:**

- **Chemistry using Microwaves:**
 - (a) Microwave heating
 - (b) Microwave assisted Reactions
- **Sonochemistry:**
 - (a) Sonochemistry and green chemistry
- **Photochemical reactions:**
 - (a) Advantages and challenges faced by Photochemical Processes.
 - (b) Example of Photochemical Reactions

Recommended Books:

1. Green Chemistry (Microwave Reactions), K.R. Desai, Himalaya Publication.
2. Green Chemistry and Introduction Text, by Mike Lancaster, Royal Society of Chemistry, Cambridge.
3. Phase Transfer Catalyst, Charles M. Sturks and Charles Liotta, Academic Press.
4. Application of biochemical system in Organic Chemistry, C.J. Sih and J.P. Rosazza Wiley, New York, 1976

UNIT-V : HETEROCYCLIC CHEMISTRY:**(15 Periods)****(1) Nomenclature of Heterocycles:**

Replacement and systematic nomenclature for monocyclic and fused heterocycles and bridged heterocycles.

(2) Aromatic Heterocycles and Heterocyclic Synthesis:

General chemical behaviour of aromatic heterocycles, Classification of heterocyclic compounds, Principles of heterocyclic synthesis involving cyclization reactions and reactivity and tautomerism of aromatic, heterocyclic compounds and their mechanism containing two heteroatoms (O, S and N) and their condensed systems.

(3) Five-membered and Benzo fused Five-membered Heterocycles:

Oxazole, Isooxazole, Thiazole, Isothiazole, Pyrazole, Imidazole, Benzoxazole, Benzthiazole, Benzopyrazole, Benzimidazole.

(4) Six-membered and Benzo fused six-membered heterocycles with two heteroatoms:

Pyridazine, pyrimidine, pyrazine, cinnoline, quinoxaline, quinazoline, morpholine, phenoxazine, naphthyridine - phenothiazine, phenazine.

Recommended Books:

1. Chemistry of Heterocyclic Compounds by Badger (Academic Press, 1963).
2. Heterocyclic Compounds by R. C. Elderfield (Ed.), Vol. 1-9 (Wiley, New York, 1960-65).
3. An Introduction to the Chemistry of Heterocyclic Compounds by R. M. Acheson (John Wiley & Sons Ltd., New York, 1967).
4. Heterocyclic Chemistry (2/e) by J. A. Joule and G. F. Smith (Van Nostrand Reinhold (UK) Co. Ltd., 1978).
5. The Chemistry of Carbon Compounds by Rodd, E. R. (Ed.), Vol. 4A to 4C (Elsevier, Amsterdam, 1957-1973).
6. Ring Index by Patterson, Capell and Walker (American Chemical Society, New York, 1960).

UNIT-VI : STEREOCHEMISTRY AND CONFORMATIONAL ANALYSIS:**(15 periods)**

Concept of isomerism, Dynamic stereochemistry, prochiral relationships, Resolution of racemic modifications. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), Chirality due to helical shape.

Conformational analysis of cyclohexanes, Decalins, perhydro-phenanthrins. Heterocyclic compounds (only comparison with carbo-cyclic compounds).

More Reference Books Recommended:

1. Advanced Organic Chemistry by Carey & Sundberg (3rd edition).
2. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
3. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell Uni.Press.
4. Principles of Organic Synthesis, R.O.C. Norman and J. M. Coxon, Blackie Academic and Professional.
5. Reaction Mechanism in Organic Chemistry, S. M. Mukherji and S. P. Singh, Macmillan.
6. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
7. Stereochemistry of Organic Compounds, P. S. Kalsi, New Age International.s

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SECTION-I

UNIT I

(15 Periods)

(A) POLYMER CHEMISTRY

Types of polymers, Stereochemistry of polymers, Mechanism of polymerization (free radical, anionic and cationic), Kinetics of free radical polymerization Number & mass average molecular mass, Molecular mass distribution, Practical significance of molecular mass, Molecular mass determination (Osmometry and Viscometry), Numericals

(B) CHEMICAL MATHEMATICS

Errors in Chemical analysis, classification of errors, nature and origin of errors, Propagation of error, Accuracy and precision, Average deviation and standard deviation and its physical significance, Normal Distribution curve and its properties. Confidence limit and probability, Statistical treatment for error analysis, student 't' test, rejection criteria and Q test, method of least square, Review of basics of differential and integral calculus.

UNIT II CHEMICAL KINETICS

(15 Periods)

Collision theory of reaction rates, steric factor, activated complex theory, ionic reactions, Factors affecting reaction rates in solution. Effect of solvent and ionic strength (primary salt effect) on the rate constant, secondary salt effects.

Kinetics and mechanism of following complex reactions in details: i) Reversible, ii) Parallel, iii) Consecutive, iv) Chain & v) Enzyme catalysed reactions . Photochemical reactions (Hydrogen-bromine and hydrogen-chlorine reactions), Oscillatory chemical reactions, classification of oscillatory reactions. Numericals

UNIT III

(15 Periods)

(A) CLASSICAL THERMODYNAMICS

Brief resume of concepts of laws of thermodynamics, free energy and entropy, Partial molar properties: Partial molar free energy, Partial molar volume, Partial molar heat content, Chemical Potential, and their significances. Determination of these quantities. Non-ideal systems: Excess functions of non-ideal solutions

(B) STATISTICAL THERMODYNAMICS

Thermodynamic probability and most probable distribution, Boltzmann Distribution law, Bose-Einstein and Fermi- Dirac statistics, partition function and its significance, Rotational, Vibrational & Electronic partition functions for diatomic molecules. Partition function and Thermodynamic function. (Boltzmann-Planck's equation, partition function & heat content, partition function & Gibb's free energy, partition function and third law of thermodynamics. Numericals.

SECTION-II

UNIT IV

(15 Periods)

(A) ELECTROLYTES IN SOLUTIONS

Debye-Huckel theory of interionic attraction (qualitative account only), relaxation effect and electrophoretic effect, Activity, activity coefficient, mean activity coefficient, activity in electrolytic solutions- relaxation between concentration and activity. Ionic strength, Determination of activity coefficient (solubility and EMF method). Dissociation constant, relation between thermodynamic

dissociation constant and dissociation function. Determination of dissociation constant by conductance method and approximate EMF method for monobasic acids. Numericals.

(B) OVER VOLTAGE

Electrolytic polarization, Decomposition potential, over voltage, concentration polarization, Measurement of over voltage, influence of current density and temperature on over voltage, Ionic discharge as the slow process at cathodes. Tafel and proton transfer theory of hydrogen over voltage. Processes at cathodes-Metal deposition. Numericals.

UNIT V

(15 Periods)

(A) MOLECULAR SPECTROSCOPY

Molecular spectra, microwave spectroscopy (Rotational spectroscopy), selection rule for rotational spectra, frequency of rotational spectral lines, vibrational spectra of diatomic molecule, isotopic effect in molecular spectra, harmonic vibration, potential energy, force constant, amplitude of vibration, Anharmonic vibration, Morse potential energy. Numericals.

(B) NUCLEAR CHEMISTRY

Radiation detectors- Gas ionization detectors- principle, Ion chambers- proportional counter, G.M. Counter-scintillation detector- principle, features, Inorganic & organic scintillators, solid state detectors, Radiochemical principle and use of tracers- Reaction- Mechanism- (esterification, hydrolysis, oxidation of fumaric acid, Friedel-Craft reaction). Structure determination, surface area of a powder, radiometric titration, Isotope dilution analysis. Neutron activation analysis. Numericals.

UNIT VI

(15 Periods)

(A) MICELLES

Surface active agents, classification of Surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, Krafft point and cloud point, counter ion binding to micelles, thermodynamics of micellization-phase separation model, solubilization, micro emulsion, reverse micelles.

(B) ADSORPTION/ COLLOIDS

Gibbs adsorption isotherms and the determination of surface area/molecule, estimation of surface area of adsorbents (BET equation), surface films on liquids, electrical double layer, electrokinetic phenomenon, Zeta potential and its determination by electrophoresis, Effect of salt on zeta potential, DLVO theory of colloid stability catalytic activity at surfaces, Numerical.

Books Recommended:

- 1) Physical Chemistry, P.W. Atkins, 6th Edition, ELBS.
- 2) Chemical Kinetics, K.J. Laidler, 3rd Edition, Harper and Row, 1987.
- 3) Micelles, Theoretical and Applied Aspects, V. Moroi, Plenum.
- 4) Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan & J. Sridhar, Wiley Eastern.
- 5) Principles of Polymer Science P Bahadur and NV Sastry Narosa 2006,
- 6) Mathematics for Chemistry, Doggett and Sucliffe, Longman.
- 7) Mathematical preparation for Physical Chemistry, F. Daniels, McGraw Hill
- 8) Quantitative Analysis, 6th Ed., R. A. Day and A.L. Underwood, Prentice – Hall of India, 1993.
- 9) Experimental Physical Chemistry: A Laboratory Textbook, A.M. Halpernand J. Reeves Scott, Foresman And Co., 1988.
- 10) Basic Chemical Kinetics by G.L. Agrawal
- 11) Chemical Kinetics, Ira N. Levine, Prentice Hall.
- 12) Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan.
- 13) Thermodynamics of Chemist, Glasstone, Van Nostrand Co.
- 14) Thermodynamic Properties of Non-electrolyte Solutions by W.E. Acree, Academic Press, 1984.
- 15) An Introduction of Chemical Thermodynamics, R.P. Rastogi and R.R. Misra, Vikas Publishing House, New Delhi.
- 16) Essentials of Nuclear Chemistry by H.J. Arnikar (Wiley Eastern Ltd., 1981).

- 17) Introduction to Polymer Science, V.R.Gowariker, N.V.Vishwanathan and Sridhar, Wiley Eastern.
- 18) Textbook of Polymer Science by Billmeyer Wiley.
- 19) Quantum Chemistry including Spectroscopy by B.K.Sen.
- 20) A Textbook of Physical Chemistry, Vol. 4, K.L.Kapoor ,McMillan, 1985.
- 21) Introduction to Molecular Spectroscopy, G.M.Barrow , McGraw – Hill.
- 22) Modern Spectroscopy, J.M.Hollas , John Wiley.
- 23) Basic Principles of Spectroscopy, R.Chang, McGraw-Hill.
- 24) Introduction to Polymer Chemistry by A.M. Lesk, Prentice – Hall Inc., 1982.
- 25) Micelles, Theoretical and Applied Aspects, V.Morol, Plenum.
- 26) Introduction to Colloid and Surface Chemistry by Shaw.
- 27) Physical Chemistry by Protuonand Marron.
- 28) Statistical Thermodynamics by Gupta M.C.
- 29) Modern Electrochemistry, Vol. 1 & 2, J.O.M. Bookris and A.K.N.Reddy.
- 30) Introduction to Electrochemistry by Glasstone.