

  
**KUVEMPU UNIVERSITY**  
**Department of PG Studies in Industrial Chemistry**  
**Shankaraghatta**

**New CBCS Scheme Course Pattern w.e.f.**

Sem	Theory Code	Max Marks 100		Credits Hrs/ Week	Credits Points	Practical Code	Max Marks 50	Credits Hrs/ Week	Credits Points	Total Credits per semester	
		Theory + IA 75 + 25									
I	IC.HC: 1.01	75	25	4	4	IC.HC : 1.05	40+10	4	2	22	
	IC.HC: 1.02	75	25	4	4	IC.HC : 1.06	40+10	4	2		
	IC.HC: 1.03	75	25	4	4	IC.HC : 1.07	40+10	4	2		
	IC.HC: 1.04	75	25	4	4						
II	IC:HC: 2.01	75	25	4	4	IC:HC: 2.05	40+10	4	2	24	
	IC:HC: 2.02	75	25	4	4	IC:HC: 2.06	40+10	4	2		
	IC:HC: 2.03	75	25	4	4	IC:HC: 2.07	40+10	4	2		
	IC:HC: 2.04	75	25	4	4						
	Elective	40	10	2	2						
III	IC:HC: 3.01	75	25	4	4	IC.HC : 3.04	40+10	4	2	24	
	IC:HC: 3.21	75	25	4	4	IC.HC : 3.05	40+10	4	2		
	IC:SC: 3.03	75	25	4	4	IC.HC : 3.06	40+10	4	2		
	IC:SC: 3.04	75	25	4	4						
	Elective	40	10	2	2						
IV	IC HC: 4.01	75	25	4	4	IC HC: 4.04	40+10	4	2	20	
	IC SC: 4.02	75	25	4	4	IC HC: 4.05	40+10	4	2		
	IC SC: 4.03	75	25	4	4	Project	75+25	4	4		
										90	
	Personality Development Programme								2		
	Communication Skills								2		
	Computer Skills								2		06
											96

**1<sup>st</sup> Semester**

**Theory papers**

IC.HC: 1.01 Analytical & Separation Techniques  
 IC HC: 1.02 Inorganic Chemistry-I  
 IC HC: 1.03 Organic Chemistry I  
 IC HC: 1.04 Physical Chemistry-I

**Practical**

IC.HC: 1.05 Inorganic Chemistry  
 IC HC: 1.06 Organic Chemistry  
 IC HC: 1.07 Physical Chemistry

**2<sup>nd</sup> Semester**

**Theory papers**

IC: HC: 2.01: Spectroscopic Techniques  
 IC HC: 2.02: Inorganic Chemistry – II  
 IC HC: 2.03: Organic Chemistry-II  
 IC HC: 2.04: Physical Chemistry - II  
 Elective

**Practical**

IC.HC: 2.05 Inorganic Chemistry  
 IC HC: 2.06 Organic Chemistry  
 IC HC: 2.07 Physical Chemistry

**3<sup>rd</sup> Semester**

**Theory papers**

IC HC: 3.01: Chemical process principles  
 IC HC: 3.02: Advanced Organic and Medicinal chemistry  
 IC SC: 3.03: Polymer Chemistry and Technology  
 IC SC: 3.04: Pollution monitoring and control  
 Elective

**Practical**

IC.HC: 3.05 Preparation, Separation and Estimation  
 IC HC: 3.06 Technical Analysis-I  
 IC HC: 3.07 Technical Analysis-II

**4<sup>th</sup> Semester**

**Theory papers**

IC HC: 4.01: Unit Operations  
 IC SC: 4.02: Organo Metallic and Bioinorganic Chemistry  
 IC SC: 4.03: Advanced Analytical Techniques

**Practical**

IC HC: 4.04: Commercial Analysis  
 IC HC: 4.05: Experiments in Polymer Chemistry  
 IC HC: 4.06: Project work and Viva-voice

**Syllabus for M.Sc. I semester  
(CBCS SCHEME)**

**IC HC: 1.01: Analytical and Separation Techniques**

**64 hrs.**

**UNIT-I**

**Evaluation of analytical data:**

Determinate and indeterminate errors, methods of minimizing errors, accuracy and precision, significant figures, mean median, standard deviation, distribution of random errors, statistical treatment of finite samples reliability of results, least square method and curve fitting. Criteria for rejection of an observation. Q, F and t test: comparison of results. Titrimetric and Gravimetric methods of analysis: Titrimetry: theory of indicators- indicator actions with examples: theoretical basis for Titrimetic analysis, classification of Titrimetic methods: acid-base, redox complex formation and precipitation titration's. Titrations in non-aqueous media. 16 Hrs

**UNIT-II**

**Gravimetry:** general principles, condition for precipitation, choice of precipitants, advantage of using organic precipitants, factors influencing the solubility of precipitates, theories of precipitation, post-precipitation, co-precipitation, effect of digestion, precipitation from homogeneous solution (PFHS), pH changes, ion release reagents, change in oxidation states, use of mixed solvents in analytical applications. 16 Hrs

**UNIT-III**

**Separation techniques:**

**Solvent extraction (liquid-liquid extraction):** General principles, nature of partition forces (dispersion, interaction, dipole-dipole interaction, induction interaction, hydrogen bond interaction); Relationship between percentage of extraction and distribution coefficient and distribution ratio, extraction of metal organic complexes and ion association complexes, multiple extraction, Craig tube. 16 hrs.

**UNIT-IV**

**Chromatographic Techniques:**

Classification, basic principle, theory of chromatography, ion-exchange chromatography, ion-exchange process, synthesis and structure of ion-exchange resin, resolution, retention parameters, selectivity ion-exchange capacity, application in the removal of interfering ions, lanthanide separation, concentration and recovery of tracer ions. **Gas Chromatography:** Characteristic of mobile, stationary phase used in GSC and GLC, characteristics of carrier gases, detectors, TCD, FID and ECD, application of GC and GC-MS. **Paper and Thin layer chromatography:** Stationary and mobile phases, various techniques of development- visualization and evolution of chromatograms, applications, separation of inorganic and organic compounds. **High performance liquid chromatography:** Scope of HPLC, introduction principle- instrumentation detectors and applications. 6 hrs.

**REFERENCES:**

01. Principles of Quantitative chemical Analysis – Robert de Levie, International edition 1997 McGraw Hill Co.
02. Quantitative Analysis – Day and Underwood, Printice Hall Indian, Pvt Ltd. 6<sup>th</sup> edition (1993).
03. Vogel’s Textbook of quantitative chemical analysis – Revised by G.H.Jaffery, J.Bassett, J.Mendhm and R.C.Denney ELBS 5<sup>th</sup> edition (1998).
04. Quantitative Chemical Analysis-D.C. Harris, W.M. Freeman and Co., NY, USA, IV Ed, 1995.
05. Introduction to Instrumental Analysis- R.D. Braun, McGraw Hill Book Company, 1982
06. Physical Methods in Inorganic Chemistry-R. Drago, Affiliated to East west Pvt., Ltd., 1968
07. Introduction to Chromatography- Theory and Practice-V.K. Srivastava and K.K. Srivastava, S.Chand Company Ltd., IV ed., 1991
08. Analytical Chromatography-G.R. Chatwal, Himalaya Publishing House, VII ed., 1998
09. Basic Concepts of Analytical Chemistry- S.M. Khopkar, New Age International Publishers, IIEd., 1998
10. Principles of Instrumental Analysis- Skoog, Hollar and Nieman, Harcourt, Asia pvt Ltd., India, New Delhi, V Ed., 1998
11. Fundamentals of Analytical Chemistry- Skoog, West and Hollar, Harcourt, Asia pvt Ltd., India, New Delhi, VII Ed., 1998

## IC HC: 1.02: Inorganic Chemistry-I

64hrs.

### UNIT-I

**Chemical bonding:** Ionic bond – Properties of ionic compounds, close packing in ionic compounds, radius ratio rule; type and structure of simple ionic compounds (NaCl, CsCl, CaF<sub>2</sub>, TiO<sub>2</sub>, perovskites and spinals); Lattice energy, Born – Lande equation, Born – Haber cycle –applications. Covalent character in ionic bonds, Fajan’s rules, percent ionic character and electronegativity values. Hydration energy and solubility of ionic solids. Covalent bond – Molecular Orbital Theory – LCAO method – sigma, pi and delta M.Os, M.O. treatment of Homo and hetero diatomic molecules. MOT of delocalised  $\pi$ -bonding system – CO<sub>3</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>.

16 hrs.

### UNIT-II

**Shapes of poly atomic molecules :** Application of VSEPR theory and geometry of covalent molecules. Role of p- and d- orbitals in sigma and pi – bonding in non – metallic compounds. Inter halogen – XY type (ClF, ICl, IBr), XY<sub>3</sub> type (ClF<sub>3</sub>, BrF<sub>3</sub>, ICl<sub>3</sub>) and XY<sub>5</sub> type (ClF<sub>5</sub>, BrF<sub>5</sub>, ICl<sub>5</sub>) – trends in each type, preparation, uses and structures. Pseudo halogens: Cyanogen, thiocyanogen and selenocyanogen – preparation and properties. Noble gas compounds: Reactivity trends, compounds of xenon (XeF<sub>2</sub>, XeF<sub>4</sub>, XeF<sub>6</sub>, XeOF<sub>2</sub>, XeOF<sub>4</sub>) and krypton (KrF<sub>2</sub>) – Preparation, reactivity and structure. 16hrs.

### UNIT-III

**Solid state:** Crystal systems and lattices, miller planes, crystal packing, crystal defects; Bragg's Law, ionic crystals, Different structures of AX, AX<sub>2</sub>, ABX<sub>3</sub> compounds. Defect in solids – types of defects, stoichiometric defects – Schottky and Frenkel defects, non-stoichiometric defects, colour centers. Band theory of solids: Metals, insulators and semi-conductors; intrinsic and photo excited and impurity and defect semiconductors; mixed oxides – spinals and perovskites, p-n junctions, high temperature super conductors. Introduction to Nanomaterials: Classifications, Synthetic Methods: - ceramic (high temperature) procedure, precursor methods, combustion synthesis, sol-gel synthesis, high-pressure synthesis and intercalation methods. Characterization of nanomaterials by UV-Visible, IR, XRD, SEM, TEM, AFM, STM technologies

16hrs.

#### UNIT-IV

**Inorganic rings, cages and polymers** : Chemistry of boranes, carboranes and mettalocarboranes – preparation, chemistry, structure and bonding. **S-N compounds (SN)<sub>4</sub>** – preparation, properties, structure and bonding; **P-N compounds**: phosphazenes – trimmer, chlorophosphazenes – trimmer, linear polymeric chlorophosphazenes – preparation, structure and bonding. **B-N compounds**: borazoles – preparation, properties, structure and bonding. **Silicone polymers** – preparation, properties, structure, bonding and applications. **Silicates and zeolites** – types, structure and applications. Isopoly and heteropoly molybdates and tungstates – properties and structures. **Modern concepts of acid and base** : Solvent system concept, relative strengths of acids and bases, leveling effect of solvents; Lux – Flood and Usanovich concepts; HSAB concept, basis of HSAB concept, acid-base strength and hardness & softness; symbiosis; application of HSAB concept.

**16hrs.**

#### REFERENCES

1. Advanced Inorganic Chemistry, (5<sup>th</sup> edition)- F.A.Cotton and G.Wilkinson; John Wiley and Sons. 1988.
2. Inorganic Chemistry : Principles of Structure and reactivity (3<sup>rd</sup> edition)- James E. Huheey, Ellen E. Keither and Richard L. Keither: Harper Collins College Pub., 1993.
3. Theoretical Inorganic Chemistry (2<sup>nd</sup> edition)- M.C.Day, Jr and J.Selbin; Affiliated East-West Press, New Delhi.
4. Concept and Models in Inorganic Chemistry (2<sup>nd</sup> edition)- Douglas, McDaniel and Alexander;
5. Concise Inorganic Chemistry – J.D.Lee; ELBS, 1991.
6. Modern Aspects of Inorganic Chemistry – H.J.Emeleus and A.G.Sharpe, ELBS.
7. Chemistry of the Elements – Greenwood and Earnshaw; Pergoman Press, Oxford, 1986.
8. Chemical Approches to the Synthesis of Inorganic Materials – C.N.R.Rao, Wiley Eastern Ltd.
9. Solid State Chemistry and its Application – Antony R. West : John Wiley & Sons.
10. Modern Inorganic Chemistry – W.L.Jolly, McGraw Hill, New York, 1984.
11. Chemistry of Nanomaterials: Synthesis, Properties and applications - C.N.R. Rao.

**IC HC: 1.03: Organic Chemistry-I****64 Hrs****UNIT I**

**Reaction intermediates:** Generation, structure, stability and reactions of carbocations, carbanions, free radicals, carbenes, nitrenes and arynes. Non-classical carbocations.

**Methods of determination of Reaction mechanism:** Kinetic and non-kinetic methods, identification of products, detection of intermediates, isotopic labeling, stereo chemical evidences, crossover experiments, kinetic evidences and kinetic isotopic effects. **Organic acids and bases:** Bronsted-Lowry and Lewis concept, Effect of substituents on strength

of acids and bases (appropriate examples to be given).

**16 hours****UNIT II**

**Nucleophilic substitution at saturated carbon:** Mechanism and stereochemistry of nucleophilic substitution reactions ( $S_N1$ ,  $S_N2$  and  $S_Ni$  reactions). Effect of solvent, nature of substrates, neighboring group participation and substitution at allylic carbon atom.

**Aromaticity:** Huckel's rule and concept of aromaticity, benzenoid and non-benzenoid aromatic compounds, anti-aromatic and non-aromatic compounds. Annulenes, azulene, heteroannulenes and fullerene. **Aromatic electrophilic substitution reactions:** Mechanism of aromatic nitration, halogenation, sulphonation, Friedel-Craft's alkylation and acylation reactions. Orientation and reactivity (directive effect of substituents).

**16 hours****UNIT III**

**Carbohydrates and nucleic acids. Monosaccharides:** Configuration and conformation of monosaccharides, ring structure of monosaccharides. Anomeric effect, Hudson's rule. Oligosaccharides: Structure elucidation of maltose and sucrose. Mention the structure of raffinose and cellobiose. Polysaccharides: General methods of structural determination of polysaccharides. Structure of cellulose starch, chitin and glycogen. Industrial applications of polysaccharide. Nucleic acids: Introduction, classification, components of nucleic acids, structure and synthesis of nucleosides and nucleotides. Crick-Watson model of DNA. Role of DNA and RNA in protein synthesis, replication, transcription and translation. Genetic code, salient features.

**16 hours****UNIT IV**

**Proteins and vitamins; Amino acids-** Classification and synthesis of amino acids (Gabriel phthalimide, melonic ester, azlactone, Darapsky, Strecker and Bucherer hydantoin methods of synthesis). Peptides: Synthesis of peptides, use of blocking reagents and deprotecting groups. Bruce-Merrifield synthesis of polypeptides. End group analysis. Brief account of primary, secondary, and tertiary structure of proteins.

**Vitamins:** Introduction, Synthesis of ascorbic acid, thiamine, riboflavin, vitamin A, biotin, vitamin E vitamin K and vitamin B12. Biological importance of vitamins.

**16 Hrs**

**References:**

1. Advanced organic chemistry: Reactions , Mechanisms and structure by Jerry March, John Wiley publications.
2. A guide Book to mechanism in organic chemistry by Peter Sykes, Longman.
3. Principles of organic synthesis by R.O.C.Norman and J.M. Coxon, Blackie Academic and professional.
4. Organic chemistry of natural products by Gurdeep R Chatwal Himalaya Publishing House.
5. Organic chemistry Vol I and II by I.L. Finar, ELBS.
6. Heterocyclic chemistry by J.A.Joule, K.Mills and G.F. Smith, Chapman and Hall.

**IC HC: 1.04: Physical Chemistry-I****64 hrs****UNIT-I**

**Chemical Dynamics and Surface Chemistry:** Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory. Arrhenius equation and the activated complex theory, ionic reactions, kinetic salt effects and steady state kinetics. Kinetic and thermodynamic control of reactions, treatment of unimolecular reactions. Adsorption-Gibbs adsorption isotherm, estimation of surface area(BET equation) surface films on liquids(Electro-kinetic phenomena), Catalytic activity at surfaces. Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration(CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization.

**16Hrs****UNIT-II**

**Nuclear and Radio Chemistry:** Radioactive series – Nuclear models, Radioactive decay – Artificial radioactivity – Nuclear reactions. – Application of radioactivity, Mossbauer spectroscopy – positron annihilation. Nuclear fission and fusion. Power and breeder reactors. Methods of accelerating nuclear particles for bombardment. Detection and measurement of activity Production and uses of radioactive isotopes and labeled compounds. Tracer chemistry, experimental techniques in the assay of isotopes. Electroscopes, counters, chamber and semiconductor radiation detectors, statistics of counting.

**16 Hrs****UNIT-III**

**Electrochemistry –I :** Electrolytic solutions, strong electrolytes, ionic atmosphere, relaxation and electrophoretic effects, quantitative treatment of Debye-Huckel theory and its extension by Onsagar. Electrochemical sensors-Ion selective electrodes, electrochemical biosensors. Electrochemical energy systems - Introduction, fundamentals of batteries, classification of batteries, sizes of batteries, battery characteristics, primary batteries, dry cell, alkaline MnO<sub>2</sub> batteries and other batteries. Secondary batteries - lead-acid, alkaline storage batteries-battery charging theory and practice. Energy economics. Fuel cells - types - electrochemistry of fuel cells.

**16 Hrs****UNIT-IV**

**Chemical Thermodynamics:** Review of basic principle of thermodynamics. concepts of free energy and entropy, combined form of first and second laws. Thermodynamic criteria for equilibrium and spontaneity. Maxwell's relations, thermodynamic equations of state. Principle of equipartition energy Physical equilibrium involving phase transitions, Clascius-Clapeyron and its application. Entropy of vaporization and Trouton's rule determination of free energy change. Third law of thermodynamics, determination of third law entropies, concept of residual entropy. Partial molar properties,, thermodynamics of ideal and real gases and gas mixtures. Fugacity, , activity, activity coefficient-different scales of activity coefficient for solute and solvent, Reaction Equilibria

**16 Hrs**

**REFERENCES:**

- 1 Physical Chemistry-Atkins, ELBS, 1982
- 2 Physical Chemistry-Barrow, McGraw Hill, Int. St. Ed., 1979
- 3 An Introduction to Chemical Thermodynamics-R.P. Rastogi and S.S. Misra, Vikash, Delhi, 1978
- 4 Thermodynamics-Rajaram and Kuriakose, East West, Nagin CX, Delhi, 1986
- 5 Chemical Thermodynamics-Klotz and Rosenberg, Benjamin Inc., 1972
- 6 Theoretical Chemistry-Glasstone, East West, 1973
- 7 Introduction to Chemical Thermodynamics-R.P. Rastogi and S.S. Misra, Vikash, Delhi, 1978
- 8 Thermodynamics-Rajaram and Kuriakose, East West, Nagin CX, Delhi, 1986
- 9 Chemical Kinetics-Laidler, Harper and Row, Delhi, 1987
- 10 Kinetics of Chemical Reactions-S.K. Jain, Vishal Publications, 1982
- 11 Theoretical Chemistry-Glasstone, East West, 1973
- 12 Kinetics and Mechanism-Moore and Perason, Wiley, 1980
- 13 Kinetics and Mechanism-Moore and Pearson, Wiley, New York, 1981.
- 14 Techniques in Organic Reaction Kinetics-P. Zumen and R.C. Patel, Wiley, New York, 1984
- 15 Kinetics of Chemical Reactions-Jain, Vishal, New Delhi
- 16 Physical Chemistry of Surfaces-Adamson, John Wiley
- 17 Modern Electrochemistry, vol. I and II-Bokris and Reddy, Plenum Press, New York, 1970
- 18 An Introduction to Electrochemistry- Glasstone, East West Ltd
- 19 Corrosion Engineering-Fountain and Green, McGraw Hill, 1969
- 20 Nuclear Chemistry-Friedlander, Kennedy and Miller, Wiley
- 21 Source Book of Atomic Energy-Glasstone, East West, New Delhi, 1967, III Ed.
- 22 Chemical and Electrochemical Energy systems-R. Narayan and B. Viswanathan, University press, 1998

**IC.HC1.05: INORGANIC CHEMISTRY PRACTICALS:**

**COMPLEXOMETRIC TITRATIONS :** Determination of calcium, determination of magnesium, determination of nickel, determination of copper, determination of lead, determination of hardness of water,

**REDOX TITRATIONS :** Determination Of Iron Using  $K_2Cr_2O_7$ , Determination of iron using ceric sulfate solution, Determination of iron using Ammonium metavanadate

**GRAVIMETRIC DETERMINATIONS :** Cu as  $CuSCN$ , Ni as  $Ni(dmg)_2$ , Al as oxinate, Determination of sulphate

**REFERENCES:**

1. Quantitative Chemical Analysis – I. M. Kolthoff, E.B. Sandell E.J.Meehan and S.Bruckenstein, McMillan Company 1968.
2. Vogel's Text Book of Quantitative Chemical Analysis G.H.Jeffery, J.Bassett, J.Mendhan and R.C. Denny, ELBS, Longman 5<sup>th</sup> edition 1989.
3. Advanced Practical Inorganic Chemistry Gurdeep Raj, Goel Publishing House, 10<sup>th</sup> edition 1994.
4. A Text Book of Quantitative Chemical Analysis A.I.Vogel, ELBS Longman 3<sup>rd</sup> edition, 1961.
5. Quantitative Analysis R.A.Day and A.L.underwood, Prentice Hall of India 1993.
6. Commercial method of analysis Snell and Biffen.

**IC.HC1.06: ORGANIC CHEMISTRY PRACTICALS:**

Systematic Qualitative analysis of organic binary mixture- Separation, purification and identification of compounds form binary mixture.

**REFERENCES:**

1. Vogel's Text Book of Practical Organic Chemistry, by furniss, Hannaford, Smith and Tatchell, ELBS Longmann.
2. Advanced Practical Organic Chemistry by N.K. Vishnoi, Vikas Publishing House
3. Handbook of Practical Organic Chemistry by Clark
4. Practical Organic Chemistry by O.P.Agrawal
5. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia, Renu Aggarwal Universities Press Pvt. Ltd. (2000)

**IC.HC1.07: PHYSICAL CHEMISTRY PRACTICALS:**

**KINETICS OF ESTER HYDROLYSIS** calculation of activation energy Relative strength of acids

**POTENTIOMETRIC TITRATION** : Estimate the amount of ferrous ammonium sulphate present in the solution

**CONDUCTOMETRIC TITRATION** : Determination of strength and amount of Hydrochloric acid in the given soluion. Determination of strength and amount of Acetic acid in the given soluion.

**ELECTROGRAVIMETRY** : Estimate the amount of copper deposited on electrode, Effect of solvent on dissociation constant of an acid.

**REFERENCES:**

1. Vogel's Text Book of Quantitative Chemical Analysis G.H.Jeffery, J.Bassett, J.Mendhan and R.C. Denny, ELBS, Longman 5<sup>th</sup> edition 1989.
2. practical Physical Chemistry. A.M. James and F.E.Prichard, Longman.
3. Findley's Physical Chemistry. B.P. Levitt, Longman.
4. Experimental Physical chemistry. R.C.Das and Behera, Tata McGraw Hill.
5. Practical Physcial Chemistry. J. b. Yadav.
6. Experiments in Physical chemistry J.C. Ghosh, Bharathi Bhavan Publishers.
7. Experimental Physical chemistry. J.W. Williams and Farrinton Daniels.

## IC:HC:- 2.01: SPECTROSCOPIC TECHNIQUES

64 Hrs.

### UNIT-I

**General Introduction to spectroscopy:** Nature and interaction of electromagnetic radiation, energies corresponding to various kinds of radiations, atomic and molecular transitions, selection rules, spectral width, factors influencing positions and intensity of spectral lines. **Electronic**

**Spectroscopy (Absorption spectroscopy):** Quantitative aspects of absorption measurements – Beer's law and its limitations, terminology associated with electronic spectroscopy, types of absorption bands and theoretical interpretation, effect of solvent and nature of  $\lambda_{\max}$  and theoretical prediction of  $\lambda_{\max}$  for polyenes,  $\alpha$ ,  $\beta$ -unsaturated aldehydes, ketones (Woodward-Fieser rules) and substituted benzene's Instrumentation, applications, quantitative and qualitative analysis, structure determination, measurement, measurements of dissociation constants of acids and bases, simultaneous determination of binary mixtures (Cu & Ni), composition of complexes.

16 Hrs

### UNIT-II

**IR Spectroscopy:** Theory of IR absorption, types of vibrations, theoretical number of fundamental modes of vibrations and group frequencies, factors affecting group frequencies and band shapes, physical state of samples, vibrational coupling, electrical effect, inductive effects, hydrogen bonding and ring structure: Instrumentation, FTIR instrument and its advantages, sample handling techniques, qualitative applications of IR – correlation chart, important regions in IR. Applications to structural elucidation of simple organic molecules: Applications of IR spectroscopy to coordination compounds, organo transition metal complexes, (N, N dimethyl acetamide, urea, thiourea, DMSO,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_2^-$ ). Far IR spectroscopy effects of coordination and symmetry of donor molecules.

16 Hrs

### UNIT-III

**Flame Photometry and Atomic Absorption Spectroscopy(AAS):** Introduction, principle, flames and flame spectra, variation of emission intensity with flames, flame background, metallic spectra in flame: total consumption and premix burners, interferences, role of temperature on absorption, atomic absorption spectroscopy, sources, hollow cathode lamp, line sources, comparative study of AAS and Flame photometry; applications of AAS and Flame photometry.

**Luminescence spectroscopy (Molecular luminescence):** Introduction, Fluorescence, excited states, deviation process, variables that affect fluorescence. Relationship between intensity and concentration, instrumentation: Basic differences in the measurement of fluorescence and phosphorescence, general scope of applications; composition of fluorimetry and phosphometry. Fluorescent indicators; applications; fluorimetric analysis of inorganic, organic, pharmaceutical and biological materials; chemiluminescence.

16 Hrs

#### UNIT-IV

**Thermal Methods of Analysis:** Introduction, thermogravimetric analysis (TGA), types of thermogravimetric analysis, principle and method. Automatic thermogravimetric analysis, instrumentation, types of recording thermobalances, sample holders, factors influencing thermograms and applications. Isothermal analysis. Differential thermal analysis (DTA), principle of working, theory and instrumentation. Simultaneous DTA-TGA curves, factors affecting results and applications. Differential Scanning calorimetry (DSC), principle of working theory, instrumentation and applications. Thermometric titrations. **Analysis Based on Magnetic Susceptibility:** Introduction, some basic concepts and definitions, measurements of magnetic susceptibility, diamagnetic substances, paramagnetic and unpaired electrons, applications.

**16 Hrs.**

#### REFERENCES:

1. Principles of Quantitative chemical Analysis – Robert de Levie, International edition 1997 McGraw Hill Co.
2. Quantitative Analysis – Day and Underwood, Printice Hall Indian, Pvt Ltd. 6<sup>th</sup> edition (1993).
3. Vogel's Textbook of quantitative chemical analysis – Revised by G.H.Jaffery, J.Bassett, J.Mendhm and R.C.Denney ELBS 5<sup>th</sup> edition (1998).
4. Spectroscopy of organic compounds – P.S.Kalasi Wiley Eastern Ltd., India, 1993.
5. Organic Spectroscopy – William Kemp, 3<sup>rd</sup> edition ELBS.(1991).
6. Quantitative Chemical Analysis-D.C. Harris, W.M. Freeman and Co., NY, USA, IV Ed, 1995.
7. Introduction to Instrumental Analysis- R.D. Braun, McGraw Hill Book Company, 1982
8. Fundamentals of Molecular Spectroscopy- C.N. Banwell, Tata McGraw Hill Book Company, 1973
9. Physical Methods in Inorganic Chemistry-R. Drago, Affiliated to East west Pvt., Ltd., 1968
10. Introduction to Chromatography- Theory and Practice-V.K. Srivastava and K.K. Srivastava, S.Chand Company Ltd., IV ed., 1991
11. Analytical Chromatography-G.R. Chatwal, Himalaya Publishing House, VII ed., 1998
12. Basic Concepts of Analytical Chemistry- S.M. Khopkar, New Age International Publishers, IIEd., 1998
13. Molecular Structure and Spectroscopy- G. Aruldas, Prentice Hall India, New Delhi, 2001
14. Principles of Instrumental Analysis- Skoog, Hollar and Nieman, Harcourt, Asia pvt Ltd., India, New Delhi, V Ed., 1998
15. Fundamentals of Analytical Chemistry- Skoog, West and Hollar, Harcourt, Asia pvt Ltd., India, New Delhi, VII Ed., 1998

## IC HC: 2.02:- INORGANIC CHEMISTRY - II

64 hrs

### UNIT-I

**Transition & inner transition elements:** Characteristic properties. **Coordination Chemistry:** Introduction, chelating and bridging type of ligands, macrocyclic ligands and nomenclature. **Preparation of Coordination Compounds:** direct reactions - substitution, oxidation, reduction, photochemical, thermal decomposition and electrochemical methods. **Detection and Characterization of Coordination Compounds:** colour change, conduction, pH, solubility, precipitate formation. UV-Visible, IR, Magnetic Susceptibility, NMR, TGA DTA EPR and Mössbauer techniques. **Stability of coordination complexes:** Thermodynamic and kinetic stability; stability constants – stepwise ( $K_n$ ) and overall stability ( $\beta_n$ ) constants, trends in  $K_n$ , relation between  $K_n$  and  $\beta_n$ . Factors affecting stability ; Irving – William series. Determination of composition: Jobs method, mole ratio method, determination of stability constants: Spectrophotometric method

16 hrs

### UNIT-II

**Isomerism in metal complexes:** Structural Isomerism – Ionisation, coordination, linkage, solvate (hydrate), ligand and polymerisation isomerism. Stereoisomerism : Geometrical (cis-trans), optical isomerism ; optical isomerism in coordination No. 4 and 6. Identification of isomeric metal complexes: conductance method, cryoscopic method, I.R. spectroscopy, X-ray diffraction, Dipole moment, NMR spectroscopy, chemical (Grinberg's) method.

16 Hrs

### UNIT-III

**Bonding in Metal Complexes:** Valence bond and Crystal Field Theory: salient features; crystal field splitting of d-orbital in octahedral, tetrahedral, tetragonal and square planar field. Magnitude of  $\Delta$ , factors affecting  $\Delta$ , CFSE evidences for crystal field stabilization: short comings of CFT evidences for covalency.

M.O. treatment of bonding in octahedral complexes involving sigma-bondings; absorption spectra of  $d^1$  and  $d^2$  systems. magnetic properties: high-spin, low-spin complexes, explanation of magnetic properties of complexes based on VBT and CFT

16 hrs

### UNIT-IV

**Electronic Spectra of Complexes:** Spectra of transition metal ions-term symbol of  $d^n$  ions, ground state terms, term splitting in crystal field, inter-electronic repulsion parameters, Orgel diagrams, Tanabe-Sugano diagrams. Selection rules and band intensities, symmetry, spin-orbit coupling and vibronic coupling effects, charge transfer spectra-LMCT and MLCT. Interpretation of electronic spectra, calculation of  $\Delta$ , B and  $\beta$ . Spectrochemical series and nephelausetic series. Spectral properties of divalent 3d metal ion complexes.**Electron transfer reactions**-inner and outer sphere mechanisms; reactions of co-ordinated ligands-substitution, addition and condensation reactions.

16 Hrs

### REFERENCES

- Advanced Inorganic Chemistry, (5<sup>th</sup> edition)-F.A. Cotton and G.Wilkinson; John Wiley and Sons. 1988.
- Inorganic Chemistry: Principles of Structure and Reactivity (3<sup>rd</sup> edition)-James E.Huheey, Ellen E.Keither and Richard L.Keither: Harper Collins College Pub.,1993.
- Theoretical Inorganic Chemistry (2<sup>nd</sup> edition)-M.C.Day, Jr and J.Selbin; Affiliated East-West Press, New Delhi.
- Concepts and Models in Inorganic Chemistry (2<sup>nd</sup> edition)-Douglas, McDaniel and Alexander;
- Concise Inorganic Chemistry-J.D.Lee; ELBS, 1991.
- Modern Aspects of Inorganic Chemistry-H.J.Emeleus and A.G.Sharpe, ELBS.
- Chemistry of the Elements - Greenwood and Earnshaw; Pergoman Press, Oxford,1986.
- Chemical Approaches to the Synthesis of Inorganic Materials – C.N.R. Rao, Wiley Eastern Ltd.
- Solid State Chemistry and its Applications – Antony R.West : John Wiley & Sons.
- Modern Inorganic Chemistry- W.L. Jolly, McGraw Hill, New York, 1984.

**IC.HC:2.03: ORGANIC CHEMISTRY-II****64 hours****UNIT I**

**Addition reactions:** Addition to C-C multiple bonds, addition reactions involving electrophiles, nucleophiles and free radicals. Cyclic mechanism, orientation and stereochemistry of addition of halogen, hydrogen halide, carboxylic acids, alcohols and amines. Addition to carbon-heteroatom multiple bonds: Electrophilic, nucleophilic and free radical addition to C=O and C=N systems.

**Elimination reactions:** Discussion of E1, E2, E1CB and E2C mechanisms. Orientation during elimination reactions. Saytzeff and Hoffmann rules. Pyrolytic eliminations. Mechanism of pyrolysis of ester of carboxylic acids. Chugaev reaction, Hoffmann degradation, Cope elimination and dehalogenation of vicinal dihalides. **16 Hrs**

**UNIT II**

**Heterocyclic compounds:** IUPAC nomenclature of heterocyclic compounds. Five membered heterocycles with one hetero atom: Synthesis and reactivity of furan, pyrrole, thiophene, benzofuran, indole and benzothiophene. Six membered heterocycles with one hetero atom: Synthesis and reactivity of pyridine, quinoline and isoquinoline **16 hours.**

**UNIT III**

**Stereochemistry:** Concept of chirality, symmetry elements and chiral structure. Absolute configuration, D, L and R, S nomenclature. Diastereomers in acyclic and cyclic systems. Conformation analysis of simple cyclic (chair and boat forms of cyclohexane) and acyclic systems (butane and 1,2-dichloroethane). Inter conversion of Newman, Fischer and Saw horse projection formulae. Optical isomerism due to molecular dissymmetry: Allenes, spiranes and biphenyls. Definitions of enantiomers, diastereomers, epimers and racemic mixtures. Cis-trans, syn-anti and E,Z notations for geometrical isomers. Determination of configuration of geometrical isomers (physical and chemical methods). **16 Hrs**

**UNIT IV**

**Selected organic named reactions and Molecular rearrangements.** Mechanisms and synthetic applications of following named reactions: Aldol, Perkin, Stobbe, Dickmann, Reimer-Tiemann, Reformatsky, Diels-Alder and Wittig's reaction. Michael addition, Robinson annulation, Oppenauer oxidation. Clemmenson, Wolf-Kishner, Meerwein-Ponndorf-Verley and Birch reduction. Stork enamine and Mannich reaction. Barton, Hoffmann-Löffler-Freytag, Shapiro and Chichibabin reaction. Mechanisms and synthetic applications of following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, benzil-benzilic acid, Fries, Wolf, Von-Richter, Neber, Sommelet-Hauser, Beckmann, Hoffmann, Lossen, Curtius, Schmidt and benzidine rearrangements. **16 Hrs**

**REFERENCES:**

- 1 Advanced Organic Chemistry – Reactions, Mechanisms and structure. By Jerry March John Wiley.
- 2 Advanced Organic Chemistry by F.A. Carey and R.J. Sundberg, Plenum.
- 3 A Guide Book to mechanism in Organic Chemistry by Peter Sykes, Longman.
- 4 Structure and Mechanism in Organic Chemistry by C.K. Ingold, Cornell University Press.
- 5 Organic Chemistry by R.T. Robinson and R.N. Boyed, Prentice-Hall.
- 6 Modern Organic Reactions, by H.O. House, Benjamin.
- 7 Principles of Organic Synthesis By R.O.C. Norman and J.M. Coxon. Blackie Academic & Professional
- 8 Reaction Mechanism in Organic Chemistry by S.M. Mukherji and S.P. Singh, MacMillan (India).

- 9 Stereochemistry of Organic Compounds. By D.Nasipuri, New Age International.
- 10 Rodd's Chemistry of Carbon Compounds Ed. S.Coffey, Elsevier.
- 11 Natural Products: Chemistry and Biological significance by J.Mann, R.S. Davidson, J.B.Hobbs, D.V. Banithrop and J.B.Horbone, Longmann, Essex.
- 12 Organic Chemistry of Natural Products. By Gurdeep R. Chatwal., Himalaya Publishing House.
- 13 Organic Chemistry Vol I & II by I.L. Finar, ELBS.
- 14 Stereochemistry of Organic Compounds. By P.S. Kalsi, New Age International.
- 15 Organic Chemistry of Natural Products. By Gurdeep R. Chatwal., Himalaya Publishing House.
- 16 Heterocyclic Chemistry by J.A.Joule. K.Mills and G.F.Smith Chapman and Hall.
- 17 Heterocyclic Chemistry; by Raj K Bansal, New Age International.

**IC HC: 2.04:- PHYSICAL CHEMISTRY - II****64 hrs****UNIT-I**

**Quantum Chemistry:** Plank's Quantum theory, Photoelectric and Compton effects, de-Broglie concept, uncertainty principle, postulates of quantum mechanics, operators: algebra of operators, properties, hermitian property of operators. Formulation of Schrödinger wave equation, significance and characteristics of wave function, eigenfunction and eigenvalues, probability distribution function, normalization and orthogonality. Application of Schrödinger wave equation to one and three-dimensional boxes (quantization of energy), harmonic oscillator, rigid rotator and hydrogen atom (separation of  $R$ ,  $\theta$ ,  $\Phi$  equation and their solutions). Quantum numbers and their characteristics. Hydrogen like wave functions, angular and radial wave functions orbital diagrams. The variation method and perturbation theory, application to the helium atom, antisymmetry and exclusion principle. Slater determinant wave functions term symbols and spectroscopic states. **16 Hrs**

**UNIT-II**

**Molecular spectroscopy:** The electromagnetic spectrum, interaction of electromagnetic radiation with matter. Quantization of different forms of energy (translational rotational vibrational and electronic) conditions of resonance and energy of absorption for various types of spectra, width and intensity of spectral lines (Doppler broadening and selection rules). The theoretical treatment of rotation, spin of diatomic molecules (rigid and non-rigid rotator models), linear polyatomics, determination of bond length, isotope effects on rotation spectra, vibrational spectra of diatomic molecules, linear harmonic oscillator modes. The anharmonicity of molecular vibrations, Morse potential and potential energy surfaces, fundamental vibration-frequencies, overtones and hot bands. Degree of freedom of polyatomic molecules, vibration, rotation spectra of diatomic and linear polyatomic molecules. PQR branches. **16 Hrs**

**UNIT-III**

**Chemical Equilibrium:** Spontaneous reactions, standard free energies change. The law of mass action, Reaction potential Homogeneous equilibrium, temperature dependence of the equilibrium constant. The van't Hoff equation, Standard Free energy change, heterogeneous equilibrium. Equilibrium constant for reactions involving real gases Le-Chatelier principle, Thermodynamic treatment of Le-Chatelier principle. **16Hrs**

**UNIT-IV**

**Industrial Electrochemistry:** Fundamental concept: Electron transfer, Mass transfer, the interplay of electron transfer and mass transport control, adsorption, electro catalysis, Phase formation in electrode reactions, properties of electrolyte solution, and the assessment of cell voltage

**Electrochemical Engineering:** general consideration, costing on electrolytic process, electrolysis parameters, principles of cell design and the addition technology of electrolysis process and typical cell design. Cyclic voltammetry and its applications.

**Organic Electrosynthesis:** The hydrodimerisation of Acetonitril, other commercial electrosynthetic process, indirect Electrosynthesis, and the future Electrosynthesis. The extraction, refining and production of metal: Electrorefining, cementation, and electrodeposition of metal powders. **16 Hrs**

**REFERENCES:**

1. Fundamentals of Physical Chemistry-Maroon and Lando, Collier Mac Millian, 1974
2. Physical Chemistry-Atkins, ELBS, 1982
3. *Physical Chemistry-Barrow, McGraw Hill, Int. St. Ed., 1979*
4. Physical Chemistry-Moore, Orient Longman, 1972
5. Physical Chemistry-Castellen, Narosa, New Delhi, III Ed
6. Physical Chemistry-Arthur W. Adamson, Academic Press
7. Physical Chemistry-Daniels and R.A. Alberty
8. Physical Chemistry-Vol. I and II, Gerasimov, MIR, Moscow
9. Chemical Thermodynamics-Klotz and Rosenberg, Benjamin Inc., 1972
10. Theoretical Chemistry-Glasstone, East West, 1973

**IC.HC. : 2.05 Inorganic Chemistry Practical**

Analysis of sodium nitrite, Analysis of hematite ore, Analysis of limestone ore, Analysis of pyrolusite ore, Estimation of copper by Iodometry, Estimation of copper and iron, Analysis of nickel as Ni(DMG)<sub>2</sub>, Analysis of copper as copperthiocyanite, Analysis of barium, Determination of hardness of water.

**IC.HC. : 2.06 ORGANIC CHEMISTRY PRACTICAL**

**One step and two step synthesis of Organic Compounds:** Acetylation of Aniline (N-Acetylation). P

Bromoacetanilide from Acetanilide, Hydrolysis of p-Bromoacetanilide to p-Bromoaniline. p-  
nitroacetanilide

from Acetanilide, Hydrolysis of p-nitroacetanilide to p-nitroaniline, Oxidation of Toluene (Side  
chain oxidation). Benzoic acid and Benzyl alcohol from Benzaldehyde (Cannizaro  
reaction). Aryloxyacetic acid from Phenol (Grignard reaction). Diazocoupling reaction.  
2-Hydroxynaphthaldehyde from 2-naphthol (Riemer-Teimann reaction).

**REFERENCES:**

1. Vogel's Text Book of Practical Organic Chemistry, by Furniss, Hannaford, Smith and Tatchell, ELBS Longman.
2. Advanced Practical Organic Chemistry by N.K. Vishnoi, Vikas Publishing House
3. Handbook of Practical Organic Chemistry by Clark
4. Practical Organic Chemistry by O.P. Agrawal

**IC.HC 2.07: PHYSICAL CHEMISTRY PRACTICALS:****KINETICS OF ESTER HYDROLYSIS**

calculation of activation energy Relative strength of acids

Potentiometric titration : Estimate the amount of ferrous ammonium sulphate present in the  
solution

Conductometric Titration : Determination of strength and amount of Hydrochloric acid in the  
given solution. Determination of strength and amount of Acetic acid in the given solution.

**Electrogravimetry** : Estimate the amount of copper deposited on electrode. Effect of solvent on  
dissociation constant of an acid.

**REFERENCES:**

1. Vogel's Text Book of Quantitative Chemical Analysis G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denny, ELBS, Longman 5<sup>th</sup> edition 1989.
2. practical Physical Chemistry. A.M. James and F.E. Prichard, Longman.
3. Findley's Physical Chemistry. B.P. Levitt, Longman.
4. Experimental Physical chemistry. R.C. Das and Behera, Tata McGraw Hill.
5. Practical Physical Chemistry. J. b. Yadav.
6. Experiments in Physical chemistry J.C. Ghosh, Bharathi Bhavan Publishers.
7. Experimental Physical chemistry. J.W. Williams and Farrington Daniels.

**Syllabus for M.Sc. III semester**  
**IC HC: 3.01: Chemical process principles**

**Unit 1**

**Units and dimensions:** Conversion to SI units, dimensional analysis for unit constants, stoichiometric and composition relationships, chemical equation, material balance. material balance (without and with chemical reaction) **16 Hrs**

**Unit II**

Techniques of material balance-direct approach-algebraic equations using tie elements, case studies in unit operation and unit process with bypass and recycle. Applications of the principles of unit operations in metallurgical and chemical industry. **16 Hrs**

**Unit III**

**Fuels and combustions-** classification and analysis of fuels, analysis of coal, energetic of fuels, heating value, calculations with combustion processes. **Steam properties:** Steam table, calculation involving the utilization of steam. Boilers- classification mountings and accessories, efficiency. **16 Hrs**

**Unit IV**

**Energy balance:** Law of conservation of energy. Thermo chemistry. Heat capacity. Sensible heat, latent heat enthalpy. Calculations involving physical and chemical changes. Thermo chemistry mixing and separation, operations and chemical processes. **16hrs.**

**REFERENCES:**

1. Transport Processes and Unit Operations (4<sup>th</sup> edition) Prentice Hall of India 1997 C.J.Geankoplis.
2. Stoichiometry (2<sup>nd</sup> edition) Tata Mc Graw Hill, Bhatt and Vora, 1970.
3. Chemical Engineering (2<sup>nd</sup> revised edition), ELBS Coulson and Richardson.
4. Unit Operations in Chemical Engineering (2<sup>nd</sup> edition) Mc Graw Hill, Mc Cabe and Smith, 1967.
5. Introduction to Chemical Engineering. Badger and Banchero, Mc Graw Hill, 1999.
6. Unit Operations in Chemical Engineering, (1<sup>st</sup> edition) Pearson Practice Series, G.C.Sekhar, 2005.

**IC.HC: 3.02: Advanced Organic and Medicinal chemistry****64Hrs****UNIT I**

**Use of the following reagents in organic synthesis:** Complex metal hydrides, Gilman reagent (lithium dimethylcuprate), lithium diisopropyl amide (LDA), dicyclohexylcarbodiimide, 1,3-dithiane, trimethylsilyl iodide, tri-n-butyl-tin-hydride, Woodward and provost hydroxylation. Osmium tetroxide, DDQ, selenium dioxide, phase transfer catalysis-Peterson synthesis, Wilkinson's catalyst and Baker's Yeast.

**16 Hrs****UNIT II**

**Photochemistry:** Bonding and antibonding orbitals, singlet and triplet states, relative energies of excited state, Jablonski diagram. Photoreduction of ketones, photooxidation, photoisomerization, photosensitization, photolysis- [Norrish type-I and type-II reactions. Di-pi-methane rearrangement, Paterno-Buchi reaction. **Pericyclic reactions:** Classification of pericyclic reactions, FMO and PMO approach to the following reactions. Electrocyclic reactions: Conrotatory and disrotatory of  $4n$ ,  $4n+2$  and allylic systems. Cycloaddition reactions: Antarafacial and suprafacial addition. Sigmatropic rearrangement: Antarafacial and suprafacial shifts involving C and H. Cope Claisen rearrangement. Woodward and Hofmann selection rules for pericyclic reactions.

**16 Hrs****UNIT III**

**General aspects of drug action:** Introduction, classification, nomenclature, theory of drug action and factors affecting drug action. Metabolism of drugs, structural features and pharmacological activity. Structure, chemistry, uses and adverse effects of the following classes of drugs. Analgesic antipyretics (non-narcotic NSAIDs): Aspirin, Ibuprofen and diclofenac. Opioid analgesic (narcotic analgesics): Morphine and Methadone. Sedative and hypnotics: Barbiturates (phenobarbitone) and Benzodiazepines (diazepam). Chemotherapeutic agents: Antibacterial, antifungal, Antiviral and Anticancer agents. Anticoagulants: Oral anticoagulants- Warfarin and Dicumarol.

**16 Hrs****UNIT IV**

**Synthesis of some typical drugs:** Sulpha drugs: Sulphanilamide, sulphapyridine and sulphathiazole. Antimalarials: Chloroquine and primaquine. Analgesics: Pethidine, paracetamol and indomethacin, Aspirin, Ibuprofen and diclofenac. Sedative and hypnotics: Phenobarbitone and diazepam. Antihistamine: Diphenhydramine. Antibiotics: Penicillin G.

**16 Hrs**

**References:**

1. Advanced organic chemistry, Reactions , Mechanisms and structure, by Jerry March, John Wiley publications.
2. A guide Book to mechanism in organic chemistry by Peter Sykes, Longman.
3. Principles of organic synthesis by R.O.C.Norman and J.M. Coxon, Blackie Academic and professional.
4. Organic chemistry of natural products by Gurdeep R Chatwal Himalaya Publishing House.
5. Organic Chemistry by P.Y. Briuce, Prentice Hall international.
6. Medicinal Chemistry by Ashutosh Kar, New Age International Publishers.
7. Pharmaceutical Chemistry by T. Higuchi and E.B. Hanssen, John Wiley and sons.
8. Pharmaceutical Chemistry by Chatwal, Himalayan Publishing House.
9. Organic chemistry Vol. I and II by I.L. Finar, ELBS.
10. Heterocyclic Chemistry by J.A.Joule and K. Mills and G.F. Smith, Chapman and Hall.
11. Vogel's Text book of Practical Organic Chemistry by ELBS Longmann.
12. Advanced practical organic chemistry by N.K. Vishnoi, Vikas publishing House.
13. Practical organic chemistry by O.P Aggarwal.
14. Comprehensive practical organic chemistry by V.K. Ahlwalia, Renu Aggarwal.

## IC SC: 3.03: Polymer Chemistry and Technology

**64 Hrs**

### UNIT-I

**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 and co-ordination and co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogenous and heterogeneous systems, Polymerization Techniques. **Polydispersion-average molecular weight concept :** Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance 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. **16Hrs**

### UNIT-II

**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 homogenous series, 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. **16Hrs**

### UNIT-III

**Testing of Polymers:** Need for testing-specifications and standards, mechanical-short term (tensile, flexural, impact, tear resistance, abrasion resistance etc.,) long term ( creep and fatigue). Electrical-conductivity, volume resistivity, surface, breakdown voltage, dielectric constant, loss factor, thermal coefficient of thermal expansion, heat distortion temperature, vicat softening point, low temperature, properties, thermal conductivity. **Solution properties of polymers:** Polymer dissolution, criteria, thermodynamics, Flory-Huggins theory, nature of polymer molecules in solution, their size and shape, theta solvent, theta temperature, thermodynamics of mixing, solution viscosities. **16 Hrs**

### UNIT-IV

**Polymer processing:** Plastics, elastomers and fibres, compounding. Processing techniques; calendaring, die casting, rotational casting, film casting, injection molding, blow molding extrusion molding, thermoforming, foaming reinforcing and fiber spinning.

**Properties of commercial polymers:** Polyethylene, polyvinyl chloride, polyamides, polyester, phenolic resins, epoxy resins and silicon polymers. Functional polymers- fire retarding polymers and electrically conduction polymers, Biomedical polymers: contact lens, dental polymers, artificial heart, kidney skin and blood cells **16 Hrs**

**REFERENCES:**

1. Text book of Polymer Science (3<sup>rd</sup> edition) F.W.Billmeyer, A Wiley-Interscience, 1984
2. Contemporary Polymer Chemistry (2<sup>nd</sup> edition), H.R.Allcock and F.W.Lampe, Prentice Hall, Englewood Cliff's, NewJersy 1981
3. Polymer Science, V.R.Gowswamy<sup>424784</sup>ariker, N.V.Viswanathan and Jayadev Sreedhar, New Age International (P) Limited, August 1996.
4. Introductory Polymer Chemistry, G.S.Misra, Wiley Eastern Limited, 1993
5. Polymer Science and Technology of Plastics and Rubbers, Premamoy Ghosh, Tata McGraw Hill, 1990
6. Polymer characterisation, Physical Techniques, D.Campbell and J.R. White, Chaopman and Hall, 1989.
7. Principles of Polymer Science Systems, F.Rodriguez, McGraw Hill Book co., 1970.

## IC SC: 3.04: Pollution Monitoring and Control

**64 hrs**

### UNIT-I

**Regulatory aspects :** Industrial emission, liquids and gases, pollution caused by various chemical industries and its overall effect on quality of human life and environment. Environmental legislation, water (prevention and control of pollution) Act 1974. its implication, applications and effectiveness in industrial pollution control, water quality management in India, Indian standards, IS – 2490, IS – 33660, IS – 2296, MINAS for sugar industries, distilleries, synthetic fiber industries, oil refineries, pesticides industry and mercury from chloralkali industry, Air(Prevention and control of pollution ) Act 1981, good analytical practices for proper assessment of pollutions, Management of regulatory requirements. **16 hrs**

### UNIT-II

**Pollution and its measurement:** Nature of industries effluents, gaseous and liquid effluents, methods of gas analysis, analysis of CO, CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>2</sub>, S, Cl<sub>2</sub>, in the gaseous effluents, particulate matter, particle size analysis AAS applications, processing of water, the free acids and bases dissolved organic and inorganic compounds like alkali and alkaline salts, SO<sub>4</sub>, PO<sub>4</sub>, NO<sub>2</sub> No, determination of iron and calcium, suspended solids, total cations and anion, estimation of industrial metals, recovery techniques, Organic trace chemicals in waste water, volatile carcinogenic matter in waste water, recovery and recycling techniques, biological methods of waste water treatment. **16 hrs**

### UNIT-III

#### **Waste water Treatment.**

- 1. Physical Methods.** : Reverse Osmosis, electro dialysis, membrane filtrare,
- 2. Chemical methods :** i) Carbonates ii) Hydroxides iii) Sulphides
- 3. Biological methods :** iodegradable materials and removal of pollutants by microorganisms, methods of waste treatment, analytical studies, food for microorganism in waste water, BOD and its measurement, activated sludge process. **16 hrs**

### UNIT-IV

#### **Instrumental Techniques in Environmental Analysis.**

Introduction, X – ray fluorescence, Electrochemical methods, Chromatographic techniques – Gas Chromatography, HPLC, Absorption spectroscopy, Monitoring techniques and methodology. **16Hrs**

#### **Reference:**

1. A.C. Stern Air pollution, Engineering control Vol. (IV) A.P.
2. P.N. Cheremisioff and R A Yound: air pollution control and design hand book Vol-I & II Dekker.
3. Liptak: Air pollution S P Mahajan: Pollution control in process industries (MH).
4. S.P. Mahajan: Pollution control in process Industries (MH).
5. Wark & Warnor : Air Pollution Origin & Control
6. A.K. De: Environment pollution analysis
7. S.M. Khopkar; Environment pollution analysis
8. K.S. Ramlho: Introduction to waste water treatment process (A.P)
9. M.J. Hammar : Water and waste water Technology (J.W)
10. R. Horne: Environmental Chemistry, Wiley

## Practical for III semester

### 1.05: Preparation, separation and Estimation

Preparation of mercuric(II)tetrathiocyanatocobaltate complex. Preparation of Sulphatobisthiourea zinc. Preparation of Tristhiourecopper(I) sulphate. Preparation of Potassium trisoxalatochromate(III) complex. Preparation of Potassiumbisoxalatocuprate(II) dihydrate complex and estimation of copper and oxalate ion. Preparation of Hexamminecobalt (III) chloride. Preparation of Chloropentamminecobalt(III) chloride. Preparation of hexamminenickel(II) chloride.

#### REFERENCES:

1. Quantitative Chemical Analysis – I. M. Kolthoff, E.B. Sandell E.J.Meehan and S.Bruckenstein, McMillan Company 1968.
2. Vogel's Text Book of Quantitative Chemical Analysis G.H.Jeffery, J.Bassett, J.Mendhan and R.C. Denny, ELBS, Longman 5<sup>th</sup> edition 1989.
3. Advanced Practical Inorganic Chemistry Gurdeep Raj, Goel Publishing House, 10<sup>th</sup> edition 1994.
4. A Text Book of Quantitative Chemical Analysis A.I.Vogel, ELBS Longman 3<sup>rd</sup> edition, 1961.
5. Quantitative Analysis R.A.Day and A.L.underwood, Prentice Hall of India 1993.
6. Commercial method of analysis Snell and Biffen.

### 3.06 Technical Analysis I:

Estimation of phenol, Estimation of aniline, Estimation of glucose, Estimation of citric acid, Determination of carbonyl group, Estimation of amide, Estimation of ascorbic acid, Determination of saponification value, Determination of iodine value, Estimation of carboxylic acid by iodometric method, Determination of cholesterol by colorimetric method, Determination of protein by colorimetric method, Determination of amino acid by colorimetric method, Determination of unsaturation by bromination method.

#### REFERENCES:

1. Vogel's Text Book of Practical Organic Chemistry, by furniss, Hannaford, Smith and Tatchell, ELBS Longmann.
2. Advanced Practical Organic Chemistry by N.K. Vishnoi, Vikas Publishing House
3. Handbook of Practical Organic Chemistry by Clark
4. Practical Organic Chemistry by O.P.Agrawal
5. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia, Renu Aggarwal Universities Press Pvt. Ltd. (2000)

### 3.07 Technical Analysis II

Estimation of iodine in iodized common salt using iodometry. Determination of partition coefficient of acetic acid in water and butanol. An experiment to determine the energy of activation. Kinetics of the iodide hydrogen peroxide clock reaction. Kinetics of corrosion of mildsteel and accelerated corrosion resistance tests. Determination of the amount of calcium in milkpowder by EDTA Complexotry. Determination of Fe in mustardseed by colorimetry and Phosphate in peas. Estimation of Phosphoric acid in cola drinks by molybdenum blue method. Determination of copper and Nickel in mixture by Electrogravimetry. Identification of metalions in a mixture polarographically. Investigation redox potential of potassium erricyanide by Cyclic Voltametry.

**REFERENCES:**

1. Vogel's Text Book of Quantitative Chemical Analysis G.H.Jeffery, J.Bassett, J.Mendhan and R.C. Denny, ELBS, Longman 5<sup>th</sup> edition 1989.
2. practical Physical Chemistry. A.M. James and F.E.Prichard, Longman.
3. Findley's Physical Chemistry. B.P. Levitt, Longman.
4. Experimental Physical chemistry. R.C.Das and Behera, Tata McGraw Hill.
5. Practical Phycial Chemistry. J. b. Yadav.
6. Experiments in Physical chemistry J.C. Ghosh, Bharathi Bhavan Publishers.
7. Experimental Physical chemistry. J.W. Williams and Farrinton Daniels.

## Syllabus for M.Sc. IV semester

### IC HC: 4.01:- UNIT OPERATIONS

**64 hrs**

#### Unit I

**Momentum transfer operations:** fluid dynamics, viscosity of fluids and Newton's law. Shell balance technique for velocity, distribution in Laminar flow in pipes and falling flow, Bernoulli's equation. Equation for pressure drop in laminar and turbulent flow through packed beds and fluidized equipment beds. Pipes and fittings, equivalent lengths of pipes, measurement of flow of fluids, pumps and gas moving equipments. Mixing and agitation operations. Dry blending, mixing of immiscible fluids and suspension of solids in liquids. **16hrs**

#### Unit II

**Heat Transfer:** Mechanism of steady state heat transfer, conduction through solids and cylinder. Conduction through solids series. Convection, forced and natural convection, mechanism of boiling and condensation, Radiation heat transfer and its application. Unsteady heat transfer and simple cases with negligible internal resistance in cooling and heating. Equations of energy exchange in heat transfer equipment like heat exchangers, condensers. Double pipe and shell and type exchanges. Jacketed vessels and coils. **16 Hrs**

#### Unit III

**Mass Transfer Principle:** molecular diffusion in gases, liquids and solids. Fick's Law and diffusion coefficient of pure components and mixtures. Mass transfer across heterogeneous gas-liquid system. Mass transfer coefficient and overall mass transfer coefficient. Principles of mass transfer in chemical reaction. **16 Hrs**

#### Unit IV

**Basic principles and Industrial Applications of the following Unit operations**

Evaporation, Drying, Absorption processes, Distillation, Crystallization, Mechanical and physical separation processes: filtration, settling sedimentation, centrifugal separation. **16 Hrs**

**REFERENCE:**

1. Transport processes and Separation process principles. C. J. Geankoplis, IV edition Prentice Hall of India 2005.
2. Chemical engineering, 2<sup>nd</sup> edition. ELBS, Coulson and Richardson.
3. Unit Operation in Chemical Engineering, 2<sup>nd</sup> edition, McCabe and Smith, McGraw Hill 1967.
4. Unit Operations –II (Heat and Mass Transfer), 9<sup>th</sup> edition, Gavhane, Nirali Prakashan 1999.
5. Unit Operations of Chemical Engineering Vol. I & II, Chattopadhyaya, Khann, Delhi 1998.

## IC SC: 4.02: ORGANO METALLIC AND BIOINORGANIC CHEMISTRY

64 hrs

### UNIT-I

**Organometallic Chemistry:** Introduction, Classification, Nomenclature, 16 and 18 electron rule, stability, classification of ligands, complexes of  $\pi$ - ligands; Metal carbonyls, metal nitrosyls, synthesis, reactions, structure and bonding; Transition metal complexes, olefin,  $\pi$ -ligands, Cyclopentadienyl, and arene complexes; Preparation, properties, structural features. Basic reactions involving in Organometallic compounds; addition, elimination, substitution and rearrangement.

16 Hrs

### UNIT-II

**Industrial application of Organo-metallic compounds:** Homogeneous catalysis; hydrogenation of olefins, Oxo-process, Wacker process, water gas shift reactions, Carbonization. Heterogeneous Catalysis; Fischer-Tropsch reaction, Ziegler-Natta polymerization. **Bioinorganic Chemistry:** Role of alkali, alkaline earth, Fe, Co, Zn, Mo and Cu metal ions in biological systems; **Transport across the membrane:** The transport mechanism, active transport across biological membrane, -  $\text{Na}^+/\text{K}^+$ -transporting ATPase and  $\text{Ca}^+/\text{Mg}^+$ -transporting ATPase, macrocyclic crown ether compounds, cryptands, spherands and ionophores.

16 hrs

### UNIT-III

**Metabolism of inorganic nitrogen:** Nitrogen assimilation in animals, nitrate reduction in protista, nitrite reduction in plants, *in vitro* and *in vivo* methods of nitrogen fixation. Nitrogenous. Photosynthesis - chlorophyll - PS-I and PS-II. **Oxygen carriers:** Introduction to porphyrin system, substituents effects on porphyrin rings, Hemoglobin (Hb) and myoglobin (Mb)-structure, stereochemistry and oxygenation of Hb and Mb; Non- heme oxygen carriers - hemerythrin and hemocyanin. Synthetic oxygen carriers.

**Electron carriers:** Iron-sulphur proteins (ferridoxins and rubredoxins). Cytochromes: classification - cytochrome C, cytochrome P-450. **Metalloenzymes :** Mechanism of enzyme action; Catalase and peroxidase, Superoxide dismutase and ascorbic acid oxidase, Alcohol dehydrogenase, carboxy peptidase-A, xanthine oxidase, aldehyde oxidase, sulfite oxidase and xanthine dehydrogenase. Vit B<sub>12</sub>-coenzyme.

16 hrs

### UNIT-IV

**Metal Complexes in Medicine:** Interaction of metal complexes with nucleic acids, Metal ion deficiency effects, toxicity of metal ions, and treatment of toxicity, chelating agents in medicine, introduction and bacterial agents, antiviral agent and anticancer agents, metal complexes as drugs and therapeutic agents.

**Nanoparticles in Medical Diagnostic and Treatment:** Introduction, Importance of Nanoparticles in Medicine: quantum dots (Silicon & Germanium,) magnetic nanoparticles (Iron, Nickel, Cobalt and their chemical compounds) in diagnostic and cancer treatment, **Polymeric nanoparticles:** controlled and sustained drug delivery, targeting of paclitaxel, doxorubicin, 5-fluorouracil to cancer cells, gold and silver nanoparticles for photodynamic therapy.

16hrs

**REFERENCES:**

1. Advanced Inorganic Chemistry, (5<sup>th</sup> edition)-F.A. Cotton and G.Wilkinson; John Wiley and Sons, 1988.
2. Inorganic Chemistry: Principles of Structure and Reactivity (3<sup>rd</sup> edition)-James E.Huheey, Ellen E.Keither and Richard L.Keither; Harper Collins college Pub.,1993.
3. Inorganic Chemistry (3<sup>rd</sup> edition) – Shriver and Atkins; Oxford University Press, 1999.
4. An Introduction to Inorganic Chemistry – Purcell and Kotz; Holt-Saunders, 1985..
5. Coordination Chemistry – F.Basalo and R.C.Johnson; W.A.Benjamin Inc.,1979.
6. Coordination Chemistry – S.F.A.Kettle.
7. The Inorganic Chemistry of Biological Processes (2<sup>nd</sup> edition) – M.N. Hughes.
8. Physical Inorganic Chemistry: A Coordination Chemistry Approach – S.F.A. Kettle; Spectrum Pub., 1996.
9. Bioinorganic Chemistry (Reprint 1987) – R.W.Hay; Ellis Horwood/John Wiley & Sons.
10. Bioinorganic Chemistry (1<sup>st</sup> SAE) – Bertin, Gray, Lippard and Valentine; Viva Books, Pvt. Ltd., New Delhi, 1998.
11. Principles of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg, University Science Books, Mill Valley, California 1994

## IC SC: 4.03: ADVANCED ANALYTICAL TECHNIQUES

**64 Hrs.**

### UNIT-I

**Nuclear Magnetic Resonance (NMR) Spectroscopy:** Types of nuclei, (classical and quantum) relaxation process-chemical shifts, mechanism of shielding, factors influencing chemical shifts, spin-spin coupling, rules governing the interpretation of first order spectra. Low and high resolution NMR, Karplus equation, line broadening, chemical exchange, Decoupling techniques, shift reagents, fluxional molecules, nuclear Over Hauser effect, COSY – 2D NMR. Continuous wave and FT NMR, Magnetic Resonance Imaging (MRI). Applications to structure elucidation of simple organic molecules. Use of NMR in paramagnetic complexes, FTNMR. <sup>13</sup>C NMR-basic theory, natural abundance of <sup>13</sup>C, chemical shift, multiplicity of signal, correlation charts, calculation of <sup>13</sup>C proton-coupled <sup>13</sup>C spectra. Spin-spin splitting of <sup>13</sup>C signals, proton decoupled spectra, off resonance decoupling compounds with aromatic rings. Applications of NMR to solids.

**16 Hrs**

### UNIT-II

**Electron Spin Resonance(ESR)Spectroscopy:** Basic principle: Interaction between electron spin and magnetic field; Origin of the spectral lines; intensity, width and position of spectral lines; Relaxation process; multiplicity in ESR hyper fine splitting; g-value and factors affecting g-value; Rules for interpretation of spectra; Zero-field splitting and Kramer's degeneracy; John-Teller distortion; isotropic and anisotropic coupling constants; Nuclear quadruple coupling interaction; spin Hamiltonian; ESR spectra of radicals containing a single set of equivalent protons – methyl, p-benzoquinone anion, cyclopentadienyl, benzene, cycloheptatrienyl anions; ESR spectra of transition metal complexes; applications.

**16 Hrs**

### UNIT-III

**Mass Spectrometry:** Introduction to basic theory, Instrumentation – mass spectrometer, methods of generation of positively charged ions, chemical ionization, fast atom bombardment (FAB), mass analyzers resolving power, molecular ion peak, base peak, meta-stable peak, modes of fragmentations, McLafferty rearrangement, Retro Diels Alder reaction, ortho effect, structural elucidation of some organic compounds, determination of appearance potential and ionization potential, determination of molecular weight and molecular formulae, applications of mass spectroscopy in quantitative and qualitative analysis.

**Applications of Spectroscopic Techniques in Structural Elucidation:** Introduction, Structural information obtainable from different types of spectra, Procedure for elucidation of molecular structure by spectroscopic methods. Composite problems.

**16 Hrs**

### UNIT-IV

**X-Ray Diffraction Techniques:**Origin and production of X-rays, interaction of X-rays with matter, absorption, scattering and diffraction. Crystal structure –unit cell, lattices, planes and Miller indices, reciprocal lattice, Bragg's law, instrumentation – applications.

**Optical Rotatory Dispersion and Polarimetry:** Plane polarized light, instrumentation, optical rotary dispersion (ORD), plane curves, Cotton effect curve. Application of optical rotation method in the determination of rate constants; acid catalyzed muta-rotation of glucose, inversion of cane sugar.

**Mossbauer Spectroscopy:** Theory and principles, experimental methods, isomer shift, quadrupole interactions, electron density, magnetic interactions; time and temperature dependent effects, Application; Iodine trihalides, Prussian blue, Trisiron dodecacarbonyl, tin halides, hexacyano ferrate and nitroprussides.

**16 Hrs**

## **REFERENCES**

1. Principles of Quantitative chemical Analysis – Robert de Levie, International edition 1997 McGraw Hill Co.
2. Quantitative Analysis – Day and Underwood, Printice Hall Indian, Pvt Ltd. 6<sup>th</sup> edition (1993).
3. Vogel's Textbook of quantitative chemical analysis – Revised by G.H.Jaffery, J.Bassett, J.Mendhm and R.C.Denney ELBS 5<sup>th</sup> edition (1998).
4. Spectroscopy of organic compounds – P.S.Kalasi Wiley Eastern Ltd., India,1993.
5. Organic Spectroscopy – William Kemp, 3<sup>rd</sup> edition ELBS.(1991).
6. Quantitative Chemical Analysis-D.C. Harris, W.M. Freeman and Co., NY, USA, IV Ed, 1995.
7. Introduction to Instrumental Analysis- R.D. Braun, McGraw Hill Book Company, 1982
8. Fundamentals of Molecular Spectroscopy- C.N. Banwell, Tata McGraw Hill Book Company, 1973
9. Physical Methods in Inorganic Chemistry-R. Drago, Affiliated to East west Pvt., Ltd., 1968
10. Introduction to Chromatography- Theory and Practice-V.K. Srivastava and K.K. Srivastava, S.Chand Company Ltd., IV ed., 1991
11. Analytical Chromatography-G.R. Chatwal, Himalaya Publishing House, VII ed., 1998
12. Basic Concepts of Analytical Chemistry- S.M. Khopkar, New Age International Publishers, IEd., 1998
13. Molecular Structure and Spectroscopy- G. Aruldas, Prentice Hall India, New Delhi, 2001
14. Principles of Instrumental Analysis- Skoog, Hollar and Nieman, Harcourt, Asia pvt Ltd., India, New Delhi, V Ed., 1998
15. Fundamentals of Analytical Chemistry- Skoog, West and Hollar, Harcourt, Asia pvt Ltd., India, New Delhi, VII Ed., 199

## **Practicals :**

**IC HC: 4.04: Commercial Analysis :** Estimation of oxygen in hydrogen peroxide, Estimation of copper as copper thiocyanate, Estimation of chlorine in bleaching powder, Analysis of cement, Analysis of nitrite, Analysis of Dolomite.

**IC HC: 4.05: Experiments in Polymer Chemistry :** Synthesis of caprolactum. Solution polymerization of methyl methacrylate. Precipitation polymerization of acrylo nitrile. Free radical polymerization of acryl amide. Viscometry of polystyrene. Surface tension of of styrene. Preparation of cellulose triacetate. Copolymerization of acrylamide and methylmethacrylate. Solution polymerization of acrylic acid. Spectral analysis of organic compounds.

**IC HC: 4.06: Project work and Viva-voice**

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