

M.Sc.  
Sem-I to IV(Chemistry)

Prospectus No. 2015125

संत गाडगे बाबा अमरावती विद्यापीठ

SANT GADGE BABA AMRAVATI UNIVERSITY

विज्ञान विद्याशाखा  
(FACULTY OF SCIENCE)

अभ्यासक्रमिका  
विज्ञान पारंगत परिक्षा (रसायनशास्त्र)  
सत्र-१ ते सत्र -४

**PROSPECTUS**  
OF  
MASTER OF SCIENCE EXAMINATION  
IN  
CHEMISTRY  
Semester -I & III, Winter 2014,  
Semester -II & IV, Summer 2015,



2014

Visit us at [www.sgbau.ac.in](http://www.sgbau.ac.in)

Price Rs. /-

PUBLISHED BY  
**Dineshkumar Joshi**  
Registrar  
Sant Gadge Baba  
Amravati University  
Amravati-444602

- 
- © 'या अभ्यासक्रमिकेतील (Prospectus) कोणताही भाग संत गाडगे बाबा अमरावती विद्यापीठाच्या पूर्वानुमती शिवाय कोणासही पुनर्मुद्रित किंवा प्रकाशित करता येणार नाही.'
- © "No part of this prospectus can be reprinted or published without specific permission of Sant Gadge Baba Amravati University"

# INDEX

## M.Sc.Part-I & Part-II (Semester I to IV) Examinations in Chemistry (Prospectus No.2015125)

| Sr.No. | Paper   | Page Nos. |
|--------|---|-----------|
| 1.     | Special Note  | 1         |
| 2.     | Ordinance No.4 of 2008  | 3         |
| 3.     | Direction No.14 of 2009   | 12        |
| 4.     | Direction No.26 of 2010   | 14        |
| 5.     | Direction No.27 of 2010   | 37        |
| 6.     | Direction No.39 of 2011   | 40        |
| 7.     | Direction No.25 of 2012   | 42        |
| 8.     | Direction No. 7 of 2014   | 46        |
| 9.     | Direction No. 8 of 2014   | 47        |
| 10.    | <b>Semester I</b>   |           |
| I      | Inorganic Chemistry   | 1         |
| II     | Organic Chemistry   | 3         |
| III    | Physical Chemistry-I  | 6         |
| IV     | Modern Methods of Separation  | 8         |
| 11.    | <b>Semester II</b>  |           |
| V      | Co-ordination Chemistry   | 14        |
| VI     | Organic Chemistry-II  | 16        |
| VII    | Physical Chemistry-II   | 19        |
| VIII   | Optical Methods and Environmental Chemistry                                 | 20        |
| 12.    | <b>Semester III</b>   |           |
| IX     | Spectroscopy-I  | 26        |
| X      | Analytical Chemistry-I  | 29        |
| XI     | Special Paper-I   | 31        |
|        | Inorganic Chemistry (Bio-inorganic Chemistry)                               |           |
| XII    | Special Paper-II  | 33        |
|        | Inorganic Chemistry (Solid State Chemistry)                                 |           |
| XI     | Special Paper-I   | 36        |
|        | Organic Chemistry (Organic Synthesis-I)                                     |           |
| XII    | Special Paper-II  | 38        |
|        | Organic Chemistry (Natural Product-I)                                       |           |
| XI     | Special Paper-I   | 40        |
|        | Physical Chemistry  |           |
| XII    | Special Paper-II  | 41        |
|        | Physical Chemistry  |           |
| XI     | Special Paper-I   | 43        |
|        | Industrial Chemistry (Heat Transfer, Unit Operations and Material Balances) |           |
| XII    | Special Paper-II  | 45        |
|        | Industrial Chemistry (Processes Economics And Industrial Management)        |           |
| XI     | Special Paper-I   | 46        |
|        | Analytical Chemistry (Adv.Separation Tech.)                                 |           |
| XII    | Special Paper-II  | 49        |
|        | Analytical Chemistry (Recent Advances in Analytical Chemistry)              |           |
| 13.    | <b>Semester IV</b>  |           |
| XIII   | Spectroscopy-II   | 54        |
| XIV    | General Analytical Chemistry  | 57        |
| XV     | Special Paper-III   | 59        |
|        | Inorganic Chemistry (Photoinorganic & Organometallic Chemistry)             |           |
| XVI    | Special Paper-IV  | 61        |
|        | Inorganic Chemistry (Materials Chemistry)                                   |           |
| XV     | Special Paper-III   | 63        |
|        | Organic Chemistry (Organic Synthesis: II)                                   |           |
| XVI    | Organic Chemistry (Natural Product-II)                                      | 64        |
| XV     | Special Paper-III   | 67        |
|        | Physical Chemistry  |           |
| XVI    | Special Paper-IV  | 68        |
|        | Physical Chemistry  |           |
| XV     | Special Paper-III   | 69        |
|        | (Unit Processes) Industrial Chemistry                                       |           |
| XVI    | Special Paper-IV  | 72        |
|        | (Chemical Processes Industries) Industrial Chemistry                        |           |
| XV     | Special Paper-III   | 75        |
|        | Analytical Chemistry (Analysis of Commercial Products)                      |           |
| XVI    | Special Paper-IV  | 78        |
|        | Analytical Chemistry (Applied Analytical Chemistry)                         |           |

## Syllabus Prescribed for M.Sc.Part-I, Semester-I (Chemistry)

## Paper-I

## Inorganic Chemistry

60hrs (4hrs/week). 12hrs/unit

50 Marks

**Unit-I A) Stereochemistry and Bonding in Main Group Compound.**

6L

VSEPR-Shape of simple inorganic molecules and ions containing lone pairs, Various stereochemical rules and resultant geometry of the compounds of non-transitional elements, Short coming of VSEPR model. Bent rule and energetic of hybridization, some simple reaction of covalently bonded molecules, d-orbital participation by non-metal.

**B) Molecular Orbital Theory:** 6L

Molecular orbital representation of polyatomic molecules with special reference to  $C_2H_4$ ,  $C_2H_6$  and CO and delocalised molecular orbital of ozone, Carbon dioxide, Nitrite, Nitrate and Benzene.

**Unit-II** 6L

**A) Metal ligand Bonding:** Splitting of d-orbital in low symmetry environments, Structural effects of orbital splitting. Jahn-Teller effects, tetragonally distorted octahedral complexes. Jahn-Teller distortion in chelate complexes. Thermodynamic effects, crystal field stabilization energies (CFSE's) for octahedral and tetrahedral complexes, correlation of crystal field stabilization energy with the related thermodynamic properties such as lattice energies, enthalpies of hydration, formation constants, stabilization of unusual oxidation states and ionization energies, structure of mineral spinels. Limitations of crystal field theory.

**B) Magnetochemistry** 6L

Concept of magnetic susceptibility, types of magnetic bodies, Magnetic properties of free ions and transition metal complexes of different geometries, factors affecting the magnetic properties, orbital splitting and magnetic properties, quenching of orbital angular momentum, and effect of ligand field on spin-orbit coupling. Temperature dependence of paramagnetism, High spin-low spin crossover, spin crossover in coordination compounds, spin equilibria, magnetic interactions, ferromagnetism and antiferromagnetism. Anomalous magnetic moments and magnetic exchange coupling. Magnetic properties of polynuclear complexes.

**Unit-III Metallic Cluster:** 12L

Boron hydrides: Classification, nomenclature, structure, bonding and topology of boranes, 4-digit coding (s, t, y, x) numbers for  $B_2H_6$ ,  $B_4H_{10}$ ,  $B_5H_9$ ,  $B_5H_{11}$  and  $B_6H_{10}$  and their utilities. Chemistry of diboranes. Acquaintance with metalloboranes, Carboranes and Metallocarboranes. Metal clusters: Occurrence of metal-metal bonds, binuclear, trinuclear, tetranuclear, and octahedral clusters. Synthesis, properties and bonding, of carbides, sulphur-nitrogen compounds, peroxo compound of boron, carbon and sulphur, oxy acids of nitrogen, Isopoly and Heteropoly acids.

**Unit-IV A) Non-aqueous solvent behavior** 6L

Inorganic solutes in organic solvents. Solvent system concept. The role of solvents in chemical reactions, effect of physical and chemical properties. Inorganic reactions in the following non-aqueous solvents: Dinitrogen tetroxide, anhydrous sulphuric acid, bromine trifluoride and reaction in molten salts.

**B) Metal-Ligand equilibria in solution:** 6L

Stability of complex ions in solution. Basic principles, Mathematical function and their interrelationship, trends in stepwise constant, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, statistical, electrostatics, chelate effect and its Thermodynamic origin ( $\Delta G, \Delta S, \Delta H$ ). Uses of stability constants in analytical chemistry, resolving of enantiomorphs. Determination of stability constants by spectrophotometric methods (Job's and Mole ratio), Bjerrum's  $p_H$  metric method, polarographic method and Conductometric method.

**Unit-V Symmetry and Group theory** 12L

Symmetry elements and symmetry operations, symmetry groups or point groups. Schoenflies symbols, point group classification, matrix representation of symmetry operations, identification of point groups ( $C_n/C_n v/C_n h/D_n h/T_d, Oh$  etc), necessary conditions for any set of elements to form a group, subgroups, classes in a group, and representation of groups. The great orthogonality theorem (without proof) and its importance. Derivation of character tables for  $C_2v$ ,  $C_3v$  points groups (construction not required), representation reducible and irreducible, and analysis of reducible representation.

**List of Books**

- 1) S. F. A. Kettle, J. N. Murrell & S. T. Teddler: Valency Theory
- 2) C. A. Coulson: Valency
- 3) J. E. Huheey :Inorganic Chemistry
- 4) F. A. Cotton & G. Wilkinson: Advanced Inorganic Chemistry 3<sup>rd</sup>, 5<sup>th</sup> & 6<sup>th</sup> Editions.
- 5) A. F. Williams: Theoretical Approach in inorganic chemistry.
- 6) A. Mannas Chanda: Atomic Structure and chemical Bonding
- 7) L. E. Orgel: An Introduction To transition metal chemistry, Ligand field theory, 2<sup>nd</sup> Edition.
- 8) J. J. Logowski: Modern Inorganic Chemistry
- 9) B. Durrant and P.J. Durrant: Advanced Inorganic Chemistry
- 10) J. C. Bailar: Chemistry of co-ordination compounds.
- 11) W. L. Jolly: Modern Inorganic Chemistry
- 12) R. S. Drago: Physical methods in inorganic chemistry.
- 13) Waddington: Nonaqueous solvents.
- 14) Sisler: Chemistry of nonaqueous solvents.
- 15) A. K. Barnard: Therotical Inorganic Chemistry
- 16) Emeleus and Sharpe: Modern Aspect of Inorganic Chemistry.
- 17) F. A. Cotton: Chemical Applications of Group theory.
- 18) Jones: Elementary Co-ordination chemistry.
- 19) B. N. Figgis: Introduction to Ligand field.
- 20) S. F. A. Kettle: Co-ordination chemistry.
- 21) M.C. Day and J. Selbin: Theoretical Inorganic Chemistry.
- 22) J. Lewin and Wilkins: Modern Co-ordination chemistry.
- 23) Gowariker, Vishwanathan and Sheedar: Polymer science.
- 24) H. H. Jattey and M. Orchin: Symmetry in chemistry.
- 25) D. Schonland: Molecular Symmetry in chemistry.
- 26) L. H. Hall: Group theory and Symmetry in chemistry
- 27) H. H. Jattey and M. Orchin: Symmetry in chemistry
- 28) R.L. Dutta and A. Simal: Elements of magneto chemistry
- 29) Inorganic Chemistry 4<sup>th</sup> Edition, P. Atkins, Oxford University Press.
- 30) Essential Trends in Inorganic Chemistry, D.M.P. Mingos, Oxford University Press

**Semester –I****Paper-II****Organic Chemistry**

60hrs (4hrs/week). 12hrs/unit

50 Marks

- Unit-I: Nature and Bonding in Organic Molecule** 12L  
 Delocalized chemical bonding, conjugation, cross-conjugation, resonance, hyper-conjugation, bonding in fullerenes.

Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternat hydrocarbons Huckel's rule, energy level of pi-molecules orbitals, annulenes, anti-aromaticity, homo-aromaticity. Aromatic character and chemistry of cyclopentadiene anion, tropyllium cation, tropene and tropelene.

- Unit-II : Stereochemistry** 12L  
 Conformational analysis of cycloalkanes (5 6 8 membered rings), decalines, effect of conformation on reactivity, steric strain due to unavoidable crowding.  
 Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, method of resolution, optical purity, enantiotopic and distereotopic atoms, groups and faces, stereospecific and stereoselective synthesis.  
 Asymmetrical synthesis, optical activity in absence of chiral carbon ( biphenyl, allenes and spiranes). Stereochemistry of the compounds containing N, P and Sulphur.
- Unit-III : Reaction mechanism: Structure and Reactivity** 12L  
 Types of mechanism, Types of reaction, thermodynamics and kinetics requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects.  
 Effect of Structure on reactivity:-  
 Resonance and field effects, Steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.
- Unit-IV: A) reactive Intermediates:** 12L  
 Classical and non-classical carbocations, Carbanions, radical anions and radical cations, Carbenes, nitrenes and arynes. General methods of generation , detection and reactivity of these intermediates. Singlet oxygen, its generation and reactions with organic substrates.
- B) Aliphatic nucleophilic substitution:**  
 The SN<sup>1</sup>, SN<sup>2</sup>, mixed SN<sup>1</sup>, SN<sup>2</sup> and SET and SN<sup>i</sup> mechanisms. Nucleophilicity, effect of leaving group, ambient nucleophiles and ambient substrates regioselectivity. The neighbouring group. Participation mechanism, substitution at allylic and vinylic carbon atoms.

Dehydration using DCC, Meyllers synthesis of aldehydes, ketones and acids.

**Unit-V: A) Aromatic Nucleophilic Substitution** 12L

A general introduction to different mechanisms of aromatic nucleophilic substitution  $S_NAr$ ,  $S_N1$ , Benzyne and  $SRN1$  mechanisms.

Reactivity effect of substrate structure leaving group and attacking nucleophile. The Von Richter, Sommet-Hauser and Smiles rearrangements.

**B) Elimination Reactions:**

The  $E_1$ ,  $E_2$  and  $E_1CB$  mechanisms orientation of the double bond. Saytzeff and Hoffman's rule. Effect of substrate structure, attacking base, leaving group and medium. Pyrolytic elimination mechanism and orientation. Cleavage of quaternary ammonium salts. Conversion of vicinal dihalides and nitro compounds to alkenes.

**BOOKS SUGGESTED-**

- Advanced organic chemistry Reaction mechanism and structure. Jerry March, John Wiley.
- Advanced organic chemistry- F.A. Carey and R.J. Sunberg, Plenum.
- A Guidebook to mechanism in organic chemistry-Peterskyes, Longman.
- Structure and mechanism in organic chemistry-C.K. Gold, Cornell University Press.
- Organic chemistry, R.T. Morrison Boyd. Prentice Hall
- Modern organic chemistry-H.O. House, Benjamin.
- Principal of organic chemistry-R.O.C. Norman and J.M. Coxon, Blackie Academic and Professional.
- Reaction mechanism in organic chemistry-S.M. Mukharji and S.P. Singh, Macmillan.
- Stereochemistry of organic compounds- D. Nasipuri, New age international.
- Stereochemistry of organic compounds- P.s.kalsi, New age international.
- Frontier orbitals and organic chemical reactions-I. Fleming.
- Orbital Symmetry R.E. Lehr & A.P. Marchand.
- Reactive intermediate in organic chemistry-N. S. Isaacs.
- Stereochemistry of carbon compounds- E.L. Eliel.
- Physical organic chemistry-J. Hine.
- Name reaction in organic chemistry Surrey.
- Advanced organic chemistry L.F. Fieser and M. Fieser.
- Vol.I & II organic chemistry - I. L. Finar.

- Modern organic chemistry- J.D. Roberts and M. C. Caserio.
- The search for organic reaction pathways (Longmann), Peter Skyes.
- Organic chemistry 5<sup>th</sup> Edition (McGraw Hill), Pine.
- Organic chemistry (Willard Grant Press Botcon), John McMurry.
- A Textbook of organic chemistry- R.K. Bansal.
- New trends in green chemistry V.K. Ahluwalia & M. Kidwai, Anamaya publishers New Delhi.
- Organic Chemistry, J. Clayden, Oxford University Press.
- Organic Chemistry, 4<sup>th</sup> Edition, G Marc Loudon, Oxford University Press.

**Semester I  
Paper-III  
Physical Chemistry-I**

60 Hours (4-Hours/week)      50 Marks      12 hours/Unit

**Unit-I Quantum Chemistry:**

- Discussion of solutions of Schrodinger equation to some model systems viz., Particle in a three dimensional box, Harmonic oscillator, Rigid rotor. The variation theorem, linear variation principle. Perturbation theory (first order & non degenerate). Application of variation method & perturbation theory to the Helium atom. 6L.
- Ordinary angular momentum, generalized angular momentum, eigen functions for angular momentum, eigen value of angular momentum. Pauli exclusion principle. Russell-Saunders terms and coupling schemes, Slater-Condon parameters, spin-orbit coupling and Zeeman splitting. Numericals. 6L.

**Unit-II Surface Chemistry :**

- Adsorption: Freundlich adsorption isotherm, Langmuir adsorption isotherm, Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids, and catalytic activity at surfaces. 6L
- Micelles: micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation & mass models, solubilization, micro emulsion, reverse micelles. Numericals. 6L.

**Unit-III Thermodynamics**

- Classical Thermodynamics: Partial molar properties. Partial molar free energy, Chemical Potential, Partial molar volume

and Partial molar heat content and their significances. Determination of these quantities. Concept of fugacity and determination of fugacity.

Non-ideal systems: Activity, Activity coefficients, Debye-Huckel theory for Activity coefficient of electrolytic solutions; Determination of Activity & Activity coefficients; ionic strength.. 6L.

- B) Non equilibrium Thermodynamics: Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow for different irreversible processes (e.g. heat flow, chemical reaction, coupled reactions and electrochemical reactions.) Transformations of the generalized fluxes and forces, phenomenological equations. Microscopic reversibility and Onsager's reciprocity relation. Numericals. 6L.

#### Unit-IV Nuclear chemistry:

- A) Properties of Nucleons & Nuclei: Nuclear size and shape, mechanical effects due to orbiting and spinning of Nucleons, magnetic quantum numbers, Principal and radial quantum numbers, Total angular momentum of the nucleus, Magnetic properties of the nucleus. Net magnetic moments of the nuclei. Numericals. 6L.
- B) Nuclear models: Liquid drop model, shell model, Fermi gas model, collective model and optical model. 6L.

#### Unit-V Chemical Dynamics:

- A) Theories of reaction rates: Collision theory, collision rates in gases, energy requirement and steric requirement. Dynamics of molecular collisions. Transition state theory: assumptions, Statistical Mechanics and chemical equilibrium, derivations of Eyring equation, Application of transition state theory to reaction between atoms and molecules (e.g. The reaction  $H + HBr \rightarrow H_2 + Br$ ) 6L.
- B) Unimolecular reactions: Lindemann-Christiansen hypothesis and Hinshelwood treatment, Marcus's extension of the RRK treatment. 3L.
- C) Reactions in solution: Solvent effect on reaction rate, Factors determining reaction rate. Numericals. 3L.

#### List of Books :

- 1) Physical chemistry by P.W. Atkins & dePaula 7<sup>th</sup> Edition
- 2) Introduction to Quantum chemistry by A.K. Chandra, Tata Mc
- 3) Quantum chemistry by Ira N. Levine.
- 4) Molecular quantum mechanics, Vol. I & II, P.W. Atkins, Oxford university press, 1970.

- 5) Statistical thermodynamics, by T.L.Hill, Addison Wesley, 1060
- 6) Chemical thermodynamics, by F.T.Wall, W.H.Freeman & Co. 1965
- 7) Irreversible thermodynamics, Theory and applications, by K.S.Forland, T. Forland, S.K.Ratje, Jonny Wiley, 1988.
- 8) Chemical Kinetics, by K.J.Laidler, 3<sup>rd</sup> Edition, Harper and row, 1987.
- 9) Chemical Kinetics-A study of reaction rate in solution, K.Conors, V.C.H.Publication 1990.
- 10) Chemical Kinetics and Dynamics, By J.I.Streinfeld, J.S. Francisco & W.I.Hase, Pritice Hall, 1989.
- 11) Kinetics and Mechanism of Chemical transformation, J.Rajraman, J. Kucriacose, Mc-Million
- 12) Molecular reaction Dynamics and chemical reactivity, R.D.Levine and R.B. Benstin, Oxford University press. 1987.
- 13) Physical Chemistry by Alberty and Silby, Jolly Wiley
- 14) Essential of Quantum Chemistry by Anant Raman.
- 15) Introduction to Relativistic Quantum Chemistry, K.G.Dyall, Oxford University Press.
- 16) Molecular Quantum Mechanics, 4<sup>th</sup> Edition, P.W. Atkins, Oxford University Press

#### Semester I

#### PAPER-IV

#### Modern Methods of Separation

60hrs(4hrs/week),

12hrs/Unit

50 Marks

#### Unit-I

12L

**Role of Analytical Chemistry:** Classification of analytical methods-classical & instrumental. Types of instrumental analysis. Selecting an analytical method. Laboratory Operations and practices. Analytical balances (Semi micro and Micro balances) and their use in analytical chemistry. Techniques of weighing and errors. Volumetric glassware cleaning and calibration of glassware. Principal and Methods of sampling, theory of sampling, pit falls and problems associated with sampling. Techniques of sampling of gases, liquids, solids and particulates. Stoichiometric calculations based on gravimetry and titrimetry analysis of commercial samples. Transmission and storage of samples. Effect of sampling uncertainties samplers's responsibility, sampling hazards.

## Unit-II

12L

**Statistical Analysis:** (Emphasis should be placed on numerical problems) Collection, Treatment and presentation of analytical data. True, standard and observed value. Definition of terms in mean and median. Errors in chemical analysis, classification of errors, nature and origin of errors. Accuracy and precision. Average deviation and standard deviation and its physical significance. Normal distribution curve and its properties. Coefficient of variation. Confidence limit and probability. Probability theorem, probability curves, comparison of analytical results. Tests for rejection of data. T-test, F-test and Q-test. Significant figures and computation rules. Least squares method for deriving calibration graph. Curve fitting, Correlation co-efficient. Limit of detection. Regression analysis and Statistical analysis of Chemical analysis.

## Unit-III

**Modern method of separation:**

12L

**Chromatography:** General principles and Classification of various techniques. Study of following chromatographic techniques: Partition Chromatography, Liquid-Liquid Chromatography, Reverse Phase chromatography. Adsorption chromatography. Principles, Techniques and applications of paper, Thin-layer, column, HPLC, Gas Chromatography, size exclusion chromatography and Electro chromatography.

## Unit-IV

**Ion exchange**

12L

**Ion-Exchange Separation:** Fundamental properties of ion exchangers. Theory of ion exchange, exchange capacity, screening effect, penetration of electrolytes into ion exchange resins, sorption of complex ions Cation and Anion exchangers, Action of ion exchange resins. Ion-exchange equilibria and ion exchange capacity. Strongly and weakly acidic cation exchangers. Strongly and weakly basic anion exchangers. Liquid ion exchangers, chelation ion exchangers, techniques of ion exchange, use of non aqueous solvents in ion exchange separation, application of ion exchange separation in determination of total salt concentration, removal of interfering ions, separation of anions and metals and application in analytical chemistry. Separation using solvent mixture.

## Unit-V

**Solvent Extraction**

12L

**Solvent Extraction:** Basic principles, Classification, Mechanism of extraction. Multiple extraction. Significance of various terms factors favouring solvent extraction,

Extraction equilibria. Quantitative treatment of solvent extraction. Synergetic effects, ion-pair extraction, salting out effect and stripping. Techniques in extraction, application of diketone, hydroxyquinoline, oximes, dithiocarbamates, xanthates, thiols, high molecular weight amines i.e. crown ethers, cryptands and calixarenes. Advantages, applications of synergistic extraction. Separation of nonmetals and metals.

**List of Books.**

1. Analytical chemistry- Problems and Solution- S. M. Khopkar, New Age International Publication.
2. Day & Underwood: Quantitative Analysis.
3. Findley: Practical Physical Chemistry:
4. A. I. Vogel A Text book of Quantitative Inorganic Chemistry, ELBS, London.
5. Strouts Galfillal: Analytical chemistry
6. Y. Lyalikov: Physicochemical Analysis
7. S. Wilson & P. Jones: Chemical Analysis Vol I
8. Meites and Thomas: Advance Analytical Chemistry. (Mc Graw Hill)
9. H.H. Willard, L.L. Merritt and J.A. Dean: Instrumental Methods of Analysis (Van Nostrand).
10. B. L. Krayner, H. H. Willard. L. Merritt, J. A. Dean & F. A. Settle: Instrumental Methods of Analysis (CBS Publishers, Delhi, 1986)
11. R. D. Brown Instrumental Methods of Chemical Analysis (Mc Graw Hill)
12. L. R. Snyder & C. H. Harvath: An Introduction to Separation Science (Wiley Interscience)
13. F. J. Wicher Robert: Standard Methods Chemical Analysis.
14. G. L. Davis Krupadanam, D. Vijaya Prasad, K. Varaprasad Rao, KLN Reddy, C. Sudhakar, Analytical Chemistry.
15. S. M. Khopkar Analytical Chemistry of Macrocyclic and supramolecular and compounds, Narosa publication.
16. R. D. Budhiraja Separation Chemistry, New Age.
17. Kaushik & Kaushik Perspectives in Environmental Studies, New Age
18. R.L. Peesok and L.D. Shield: Modern Methods of Chemical Analysis.
19. Data Analysis for Chemistry, D.B. Hibbert, Oxford University Press.
20. Analytical Chemistry, S.P.J. Higson, , Oxford University Press

**Semester I****Organic Chemistry Practical-I**

Total Hours: 90 hrs. (9 Hours per week)

Marks: 100

**Unit-I Organic Synthesis**

Student is expected to carry out minimum of 8-10 organic preparation (involving two steps) from the following lists.

1. Preparation of Benzanilide from Benzophenone.
2. Preparation of p- nitroaniline from Acetanilide.
3. Preparation of p-Bromoaniline from Acetanilide.
4. Preparation of m-nitroaniline from Nitrobenzene.
5. Preparation of p-Chlorotoulene from p-Toluidine.
6. Preparation of p- nitrobenzoic acid from p-Nitrotoulene.
7. Cannizzaro's reaction with 4-Cholobenzaldehyde as a substrate.
8. Preparation of 2-Phenylindole (Fischer-Indole synthesis).
9. Claisen ó Schmidt: Dibenzal acetone from benzaldehyde.
10. Preparation of Anthranilic acid. (Hoffman's bromamide reaction).
11. Diels ó Alder reaction: Anthracene + Maleic anhydride.
12. Methyl ó orange from Sulphanilic acid.
13. Hydroquinone to 2,5-Dihydroxyacetophenone.
14. Chlorobenzene to 2,4- Dinitrophenylhydrazine.
15. Nitrobenzene to p- Aminophenol.

**UNIT-II Quantitative Analysis**

Student is expected to carry out following estimations (minimum 6 estimations.)

1. Estimation of Vitamin ó C ó Iodometry.
2. Estimation of Phenol by KBrO<sub>3</sub>-KBr.
3. Estimation of Amine by Bromate/ Bromide solution.
4. Estimation of Formaldehyde by Iodometry.
5. Estimation of Glucose by Benedict's solution.
6. Estimation of given carbonyl compound by hydrazone formation.
7. Estimation of Aldehyde by Oxidation method.
8. Determination of percentage of number of hydroxyl group in an organic compound by acetylation method.

**Practical-I****Organic Chemistry**

Time : 6-8 Hrs.

(One day Examination)

Marks : 100

- (1) Exercise-1 (Organic Synthesis) - 40 Marks
- (2) Exercise-2 (Qualitative Analysis) - 40 Marks

(3) Record

-10 Marks

(4) Viva-Voce

-10 Marks

**Semester I****Practical II****Physical Chemistry****Total Hours: 90 hrs.****9 Hours per week****Time: 6 – 8 hrs.****Marks: 50****Use of Computer Programs 5 terms of practicals :**

Treatment of experimental data, X-Y plots, programs with data preferably from physical chemistry practicals. Students will operate two packages I) MS-Word and II) MS-Excel.

**Part –A**

- 1) To study the surface tension-concentration relationship for solution and determination of surface excess concentration by using Gibbs's adsorption equation.
- 2) To find out the molecular surface energy and the association factor of ethyl alcohol.
- 4) To compare the cleansing power of two samples of detergent by surface tension method.
- 5) To study the effect of concentration of an electrolyte (KCl, NaCl) on solubility of an organic acid.
- 6) To study the kinetics of iodine clock reaction.
- 7) To study the reaction between acetone & iodine in presence of acids.
- 8) To study the decomposition of hydrogen peroxide catalyzed by iodine ion.

**Part- B**

- 1) To measure refractometrically average polarisability of some common solvents.
- 2) To find out the order of reaction and velocity constant of inversion of cane sugar by acid polarimetrically.
- 3) Polarimetric determination of the specific rotation of camphor in benzene and carbon tetrachloride.
- 4) Determine the rate constant, order of reaction and energy of activation of saponification of ethyl acetate by sodium hydroxide conductometrically.
- 5) To find out degree of dissociation constant of acetic acid and monochloroacetic acid by conductometrically.
- 6) Determination of strength of strong and weak acid in given mixture conductometrically.



- 7) To determine equivalence conductance of strong electrolytes at several concentrations and verification of Debye-Huckel Onsagar principle conductometrically.
- 8) Determination of solubility and solubility product of sparingly soluble salts ( $PbSO_4$ ,  $BaSO_4$ ) conductometrically.
- 9) To find out composition of ferric ion thiocyanate/Nickel and o-phenanthroline complex by Job's method by colorimetrically
- 10) To study the complex formation between ferric and salicylic acid and find the formula and stability constant of the complex colorimetrically.
- 11) To determine the dissociation constant of phenolphthalein colorimetrically
- 12) To determine the dissociation constant of Cu (II) and Fe (III) solution photometrically by titrating it with EDTA

### Practical-II

#### Physical Chemistry

|                                       |             |
|---------------------------------------|-------------|
| Time : 6-8 Hrs. (One day Examination) | Marks : 100 |
| (1) Exercise-1 (Instrumental)         | - 40 Marks  |
| (2) Exercise-2 (Non-Instrumental)     | - 40 Marks  |
| (3) Record                            | - 10 Marks  |
| (4) Viva-Voce                         | - 10 Marks  |

#### List of Books:-

1. Findley's Practical Physical Chemistry, B.P. Levitt Longman.
2. Practical Physical Chemistry, A.M. James and F.F. Prichard Longman.
3. Experimental Physical Chemistry, R.C. Das and B.Behra, Tata McGraw Hill.
4. Advanced Physical Chemistry Experimentals Gurtu-Gurtu Pragati Prakashan
5. Experimental Physical Chemistry, V.D. Athanale and Parul Mathur New age International
6. Advance Practical Physical Chemistry J.B. Yadao Goel Pubs. House.
7. Experimentals in Physical Chemistry by Dr. D.V.Jahagirdhar.
8. Experiments in Physical Chemistry by D.P.Shoemaker.
9. Systematic experimental Physical Chemistry by Dr. T.K. Chandhekar & S.W. Rajbhoj.

### Syllabus for Semester II

#### Paper V

#### Co-ordination Chemistry

60hrs (4hrs/week). 12hrs/unit

50 Marks

#### Unit-I

12L

**Ligand field theory (LFT)**, Failure of ionic model of CFT. Experimental evidences in support of metal ligand orbital overlaps, Adjusted crystal field theory (ACFT), Molecular Orbital Theory: Ligand symmetry orbitals, Sigma and pi-molecular orbitals, Qualitative treatment of MOT of Octahedral complexes with sigma bonding and also with sigma and pi bonding. Qualitative MO diagrams and their interpretation of octahedral, tetrahedral and square planer complexes with example. Explanations of charge transfer spectra. Comparison of theories of bonding-VBT, CFT, LFT and MOT.

#### Unit-II

12L

#### Electronic spectra:

Spin-orbit (L-S) coupling scheme, calculation of spectral term symbols for ground state and excited states, selection rules, vibronic coupling, electronic spectra of transition metal complexes, charge transfer spectra, band intensities, band energies, band width & shapes, construction and application of Orgel diagrams, Tanabe-Sugano diagrams, spectra of octahedral, tetrahedral and square planar complexes with examples, Jahn-Teller effect, calculation of crystal field parameters ( $10Dq$ ,  $B$ , and  $C$ ) for octahedral Ni (II) and Co(II) complexes from electronic spectra. Spectrochemical series, Nephelauxetic effect and Nephelauxetic series of ligands. Magnetic moment, electronic spectra and structure of complexes.

#### Unit-III

#### Reaction Mechanism of Transition Metal complexes -I

12L

Reactivity of metal complexes, ligand replacement reaction: classification of mechanism and energy profile of reaction. Inert and labile complexes, interpretation of lability and inertness of transition metal complexes on the basis of VBT and CFT. Factors affecting the lability of a complex, transition state or activated complex, substrate, attacking reagents electrophilic and nucleophilic, Nature of central atom. Kinetic application of CFT. Kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism,

direct & indirect evidences in favour of conjugate mechanism, anation reaction, reaction without metal ligand bond cleavage, reactions of coordinated ligands. Molecular rearrangement complexes. Geometrical, linkage and optical isomerization reactions. Ligand stereospecificity.

**Unit-IV Reaction Mechanism of Transition Metal complexes -II** 12L

Substitution reaction in square planer complexes: the trans effect, cis effect, steric effect, solvent effect, effect of leaving group, effect of charge, effect of nucleophile, effect of temperature. Trans effect theories, uses of trans-effect, mechanism of substitution reactions in Pt(II) complexes. Electron transfer reactions. Types of electron transfer reactions, conditions of electron transfer, and mechanism of one-electron transfer reactions, outer sphere and inner sphere mechanisms, two electron transfer reactions-complimentary and non-complimentary reactions. Tunneling effect, cross-reaction, Marcus-Hush theory, bridged activated mechanism. Synthesis of coordination compounds using electron transfer reactions. Photochemical reaction of Chromium and Ruthenium complexes.

**Unit-V Metal pi-Complexes:** 12L

Metal carbonyls: Structure and bonding, vibrational spectra of metal carbonyls for bonding and structure elucidation, important reaction of metal carbonyls, Metal nitrosyls: Nitrosylating agents for synthesis of metal nitrosyls, vibrational spectra and X-ray diffraction studies of transition metal nitrosyls for bonding and structure elucidation, important reactions of transition metal nitrosyls, structure and bonding. Dinitrogen and dioxygen complexes; Wilkinson's catalyst and Vaska's compound. Fluxional Organometallic compounds ( $h^2$ -olefin,  $h^3$ -allyl and dieny complexes)

**List of Books**

1. J.E.Huheey :Inorganic Chemistry
2. F.A.Cotton& G. Wilkinson: Advanced Inorganic Chemistry 3rd, 5th & 6th Editions.
3. A.F. Willims: Theoretical Approach in inorganic chemistry.
4. Mannas Chanda: Atomic Structure and chemical Bonding
5. L. E. Orgel: An Introduction To transition metal chemistry, Ligand field theory, 2nd Edition.
6. J. J. Logowski: Modern Inorganic Chemistry

7. B.Durrant and P.J.Durrant: Advanced Inorganic Chemistry
8. J.C. Bailar: Chemistry of co-ordination compounds.
9. W. L. Jolly: Modern Inorganic Chemistry Jones: Elementry Co-ordination chemistry.
10. B. N. Figgis: Introduction to Ligand field.
11. M.C.Day and J.Selbin: Therotical Inorganic Chemistry.
12. J. Lewin and Wilkins: Modern Co-ordination chemistry.
13. Purcell and Kotz: Inorganic Chemistry.
14. D. Banerjea: Co-ordination chemistry, Tata Mc. Graw. Pub.
15. A.F. Wells: Structural inorganic chemistry, 5th Edition, Oxford.
16. S. G. Davies: Organotransition metal chemistry applications to organic synthesis.
17. R. C. Mehrotra: Organometallic chemistry Tata McGraw Hill. Pub.
18. G. S. Manku: Thereotical priciples of inorganic chemistry
19. A. B. P. Lever: Inorganic electronic spectroscopy.
20. R.C.Maurya:Synthesis and charecterisation of novel nitrosyls compounds, Pioneer Pub. Jabalpur 2000.
21. R.H.Crabtree:The Organometallic chemistry of Transition metals, John Wiley.
22. D.N.Styanaryan:Electronic Absorption Spectroscopy and related techniques, University Press.
23. R. S. Drago: Physical methods in inorganic chemistry
24. F.Basolo &G.Pearson: Inorganic Reaction Mechanism
25. Organometallics II & I complexes with transition metal- carbon bonds: Manfred Bochmann- Oxford Press.
26. Advanced Inorganic Chemistry Vol I & II ó Satyaprakash, Tuli, Bassu and Madan- S Chand.
27. M.Tsusui,M.Nlevy,M.Ichikwa and K.Mori:Introduction to metal pi-complexe chemistry,Plenum press,NY
28. A.E.Martel;Coordination Chemistry-VolI&II,VNR.

**PAPER VI**

**ORGANIC CHEMISTRY-II**

60hrs (4hrs/week). 12hrs/unit

50 Marks

**Unit-I : AROMATIC ELECTROPHILLIC SUBSTITUTION** 12L  
The arenium ion mechanism,orientation and reactivity,energy profile diagrams.The o/p ratio, ipso attack,orientation in benzene ring with more than one substituents, orientation in other ring system. Diazonium coupling, Gatterman-koch reaction, Pechman reaction,Houben óhoesch reaction.

**Unit-II: A) ADDITION TO CARBON – CARBON MULTIPLE BOND 12L**

Mechanistic and stereochemical aspects of addition reaction involving electrophiles, nucleophiles and free radicals, regio and chemoselectivity, Orientation and stereochemistry, Addition to cyclopropanes, Hydrogenation of double bond and triple bonds. Hydrogenation of aromatic rings, hydroboration, Michael reaction.

**B) Addition to Carbon-Heteroatom multiple bonds.**

Mannich reaction, Lithium-Aluminium Hydride, reduction of carbonyl compounds, nitriles, Reformatsky reaction, Aldol Condensation, Knoevenagel reaction, Perkin Witting, Stobbe reaction, Hydrolysis of esters and amide, ammonolysis of esters.

**Unit-III : FREERADICAL REACTION 12L**

Type of free radical reactions, free radical substitution mechanism at an aromatic substrate, aliphatic substrate, reactivity at a bridgehead position. Neighbouring group assistance, reactivity for aliphatic and aromatic substrates, reactivity in attacking radicals, effect of solvent on reactivity.

Halogenation at an alkyl carbon, allylic carbon, hydroxylation at an aromatic carbon by means of Fenton's reagent. Oxidation of aldehydes to carboxylic acids. Chlorosulphuration (Reed Reaction) Coupling of alkynes and arylation of aromatic compounds by Diazonium salts. Sand Meyer reaction. Free radical rearrangement, Hunsdiecker reaction.

**Unit-IV : MECHANISM OF MOLECULAR REARRANGEMENT 12L**

Classification and General mechanistic treatment of electrophilic, nucleophilic and free radical molecule rearrangement. Mechanism of the following rearrangement: Wagner-Meerwein, Pinacol-Pinacolone, Tiffeneau, Demjanov ring expansion, Favorski, Wolff, Fritsch-Butenber-Wiel, Curtius Lossen, Beckmann, Hoffman, Schmidt rearrangement.

**Unit-V : GREEN CHEMISTRY 12L**

Designing a green synthesis: Choice of starting material, choice of solvents. Basic principle of green chemistry: Prevention of waste by products, Maximum incorporation of the reactants (starting material and reagents) into the final products. Rearrangements reaction, Addition reaction, substitution, elimination reaction. Prevention or

minimization of hazardous products. Designing of safer chemical. Synthesis involving basic principles of green chemistry, some examples. Synthesis of styrene, Synthesis of urethane, Free radical bromination, Synthesis of paracetamol, Synthesis of Ibuprofen.

**BOOKS SUGGESTED-**

- Advanced organic chemistry: Reaction mechanism and structure. Jerry March, John Wiley.
- Advanced organic chemistry- F.A. Carey and R.J. Sunberg, Plenum.
- A Guidebook to mechanism in organic chemistry- Peterskies, Longman.
- Structure and mechanism in organic chemistry- C.K. Gold, Cornell University Press.
- Organic chemistry, R.T. Morrison Boyd. Prentice Hall
- Modern organic chemistry- H.O. House, Benjamin.
- Principles of organic chemistry- R.O.C. Norman and J.M. Coxon, Blackie Academic and Professional.
- Reaction mechanism in organic chemistry- S.M. Mukharji and S.P. Singh, Macmillan.
- Stereochemistry of organic compounds- D. Nasipuri, New age international.
- Stereochemistry of organic compounds- P.S. Kalsi, New age international.
- Frontier orbitals and organic chemical reactions- I. Fleming.
- Orbital Symmetry: R.E. Lehr & A.P. Marchand.
- Reactive intermediate in organic chemistry- N. S. Isaacs.
- Stereochemistry of carbon compounds- E.L. Eliel.
- Physical organic chemistry- J. Hine.
- Name reaction in organic chemistry: Surrey.
- Advanced organic chemistry: L.F. Fieser and M. Fieser.
- Vol. I & II organic chemistry - I. L. Finar.
- Modern organic chemistry- J.D. Roberts and M. C. Caserio.
- The search for organic reaction pathways (Longman), Peter Skyes.
- Organic chemistry 5<sup>th</sup> Edition (McGraw Hill), Pine.
- Organic chemistry (Willard Grant Press Botcon), John McMurry.
- A Textbook of organic chemistry- R.K. Bansal.
- New trends in green chemistry: V.K. Ahluwalia & M. Kidwai, Anamaya publishers New Delhi.
- Heterocyclic Chemistry, John Joule, Oxford University Press.

**Paper- VII****Physical Chemistry-II**

60 Hours (4-Hours/week)

50 Marks

12 hours/Unit

**Unit-I Chemical Dynamics:**

- A) Kinetics of Complex reactions: Chain reaction ( $H_2 + Br_2 \rightarrow 2 HBr$  thermal and photo chemical reaction), Homogeneous catalysis (acid-base and enzymes), oscillating reactions (Belousov-Zhabotinsky reaction, Lotka-Volterra mechanism, the brusselator and the oregonator). 6L
- B) Fast reactions: General features of fast reactions, Stopped flow method, relaxation method, nuclear magnetic resonance method, flash photolysis. Numericals. 6L

**Unit-II Quantum Chemistry:**

- A) Molecular orbital theory: Basic ideas, criteria for forming M.O. from A.O., Construction of M.O. by LCAO for  $H_2^+$  ion. Calculation of energy levels from wave functions, physical picture of bonding & anti-bonding wave functions, concept of orbitals and their characteristics. 6L
- B) Hybrid orbitals-  $sp$ ,  $sp^2$ ,  $sp^3$ . Calculations of coefficient of A.O. used in hybrid orbitals. Huckel theory of conjugated systems, bond order & charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclo- butadiene. Numericals. 6L

**Unit-III Macromolecules:**

- A) Definition of macromolecule (Polymer), types of polymers, Random coils, configuration and conformation of macromolecules, electrically conducting molecular wires, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization. The stability of biological polymers. 6L
- B) Number average & mass average molecular mass, molecular mass determination by Osmometry, Viscometry, Ultracentrifugation, Electrophoresis, Size-exclusion chromatography and Light scattering methods. Numericals. 6L

**Unit-IV Electrochemistry:**

- A) Electrochemistry of solutions: Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Theory of electron transfer processes, electron tunneling. The electrode-solution interface, structure of electrified interface, electric potential at the interface. 6L

- B) The rate of charge transfer, the Butler-Volmer equation, the low overpotential limit, the high overpotential limit, Tafel plot. Voltammetry, concentration polarization, experimental techniques. Corrosion, types of corrosion, corrosion inhibitors, corrosion monitoring and prevention methods. Numericals. 6L

**Unit-V Statistical Thermodynamics**

- A) Concept of distribution, Thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and micro-canonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). 6L
- B) Partition function- Translational, rotational, vibrational and electronic partition functions, calculations of thermodynamic properties in terms of partition functions. Applications of partition functions. Numericals. 6L

**List of Books:**

- 1) Physical chemistry by P.W. Atkins & dePaula 7<sup>th</sup> Edition
- 2) Molecular reaction Dynamics and chemical reactivity, R.D. Levine and R.B. Benstin, Oxford University press. 1987.
- 3) Physical Chemistry by Alberty and Silby, Jolly Wiley
- 4) Adsorption and Catalysis by solids, by D.K. Chakraborti, Wiley Eastern, 1990
- 5) The Theory of Adsorption and catalysis, by A. Clark, Academic press, 1970
- 6) Micells Theoretical and applied aspects, by V. Moroy. Plenum
- 7) Modern Electrochemistry by A.K.N. Raddy
- 8) Theoretical electrochemistry by D.I. Antropov, Mir Publisher 1972
- 9) Electrochemistry by J. Dvorak, J. Koryta, V. Bohackova.
- 10) Introduction to radiation chemistry by J.W.T. Spinks and R.J. Woods

**Paper VIII****Optical Methods and Environmental Chemistry**

60hrs(4hrs/week), 12hrs/Unit

50Marks

**Unit-I Optical Method**

12L

**Spectrophotometry and Colorimetry:** Interaction of radiations with matters, Fundamental laws of Spectrophotometry. Beer's Lambert's law and its limitation. Verification of Beer's law and deviation from Beer's law. Ringbom's plot. Photometric titrations.  $pK$  value of indicator. Outline of construction and working of the UV-Visible spectrophotometers. (Single and double beam).

Applications of quantitative and qualitative analysis, problems.

Theory, instrumentation and applications of fluorimetry, Nephelometry, turbidimetry, Polarimetry & Refractometry.

**Unit-II Flame Emission and atomic spectrometry: 12L**

Flame photometry: Elementary theory of flame photometry. Instrumentation and experimental techniques. Interferences, analytical techniques and applications. Atomic absorption spectrometry (AAS): introduction, principles, Advantages of AAS over FES, Instrumentation, Flame atomization. Hollow cathod lamps, interferences and applications. Comparison of atomic absorption with atomic emission methods.

**Unit-III WATER POLLUTION 12L**

Origin of wastewater, types, water pollutants and their effects. Sources of water pollution, domestic, industrial, agricultural soil and radioactive wastes as sources of pollution. Objective of analysis, parameter for analysis colour, turbidity, total solid, conductivity, acidity, alkalinity, hardness, chloride, sulphate, fluoride, silica, phosphates and different forms of nitrogen. Heavy metal pollution, public health significance of Cadmium, Chromium, Copper, Zinc Lead, Manganese, Mercury and Arsenic. General survey of instrumental techniques for the analysis of heavy metals in aqueous systems. Oxygen content of water and aquatic life. Measurements of DO, BOD, COD and their significance as pollution indicators. Pesticides as water pollutants and analysis. A brief idea of coagulation and flocculation.

**Unit-IV AIR POLLUTION 12L**

Sources and sinks of gases pollutants, classification of air pollutants, effect of air pollutants on living and non-living things. Sources of air pollution, air quality standards and sampling. Analysis of air pollutants (CO, CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, H<sub>2</sub>S, NH<sub>3</sub> and Hydrocarbons and particulates). Green house effect, acid rain, ozone depletion and their consequences on environment. Effects of air pollution, photochemical smog and monitoring of air pollution.

**Unit-V Soil Pollution and Pesticide Analysis 12L**

Chemistry of soil, soil irrigation by effluents. Agricultural pollution, role of micronutrients in soil, trace element analysis in soil

Pesticides and pollution, Sources of pesticide residue in the environment, classification of pesticides, pesticide degradation by natural forces, effect of pesticide residue on life. Analytical techniques for pesticide residue analysis. DDT problem.

**Radiation pollution**-Classification and effects of radiation. Effects of ionizing radiation on Man. Effect of nonionizing radiation on life, Radioactivity and nuclear fall out, protection and control from radiation.

**List of Books**

1. Analytical chemistry- Problems and Solution- S. M. Khopkar, New Age International Publication.
2. Day & Underwood: Quantitative Analysis.
3. Findley: Practical Physical Chemistry:
4. Vogel : A Text book of Quantitative inorganic Chemistry, ELBS, London.
5. Strouts Galfillal: Analytical Y. Lyalikov: Physocochemical Analysis
6. S. M.Khopkar:Basic concept in Analytical Chemistry
7. Meites and Thomas: Advance Analytical Chemistry. (Mc Graw Hill)
8. H.H.Willard ,L.L.Merritt and J.A.Dean: Instrumental Methods of Analysis (Van Nostrand).
9. B. L. Krayner, H. H. Willard. L. Merrit, J. A. Dean & F. A. Settle: Instrumental Methods of Analysis (CBS Publishers, Delhi, 1986)
10. R. D. Brown, Instrumental Methods of Chemical Analysis ,McGraw Hill
11. L. R. Shyder & C. H. Harvath: An Introduction to Separation Science (Wiley Interscience).
12. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
13. Environmental Chemistry, Sharma & Kaur, Krishna publishers.
14. Environmental Chemistry, A. K. De, Wiley Eastern.
15. Environmental Pollution Analysis, S. M. Khopkar, Wiley Eastern.
16. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
17. Elemental Analysis of Airborne Particles, Ed. S. Landberger and M. Creatchman, Gordon and breach Science Publication.
18. Atmospheric pollution, W. Buch, McGraw Hill, New York.
19. Fundamentals of Air Pollution, S. J. Williason, Addison ó Wesley Publishers.
20. Analytical Aspect of Environmental Chemistry, D. F. S. Natush and P. K. Hopke. John Wiley & sons. New York.

21. Analytical chemistry- Problems and Solution- S. M. Khopkar, New Age.
22. Environmental Chemistry, J.W.Vanloon, Oxford University Press.

### Semester II

#### Practical III

#### Physical Chemistry

**Practical Work load (9Hours/week) Duration: 6Hours Marks : 100**

#### Use of Computer Programs 5 terms of practicals.

Treatment of experimental data, X-Y plots, programs with data preferably from physical chemistry practical. Students will operate two packages I) MS-Word and II) MS-Excel.

#### Part A

- 1) To find out molecular weight of given liquid by steam distillation method.
- 2) To find out the molecular weight of sulphur, alpha-naphthol and biphenyl by freezing point method using naphthalene as a solvent.
- 3) To find out degree of association of benzoic acid in benzene by cryoscopy method.
- 4) To study the effect of temperature on adsorption.
- 5) To determine the viscosity of different mixture benzene, nitrobenzene and also test the validity of Kendall's method.
- 6) Identify and separate given mixture of amino acid by paper chromatography.
- 7) Separation of metal cations (Co, Ni, Zn, Mn) and the Rf value by paper chromatography.
- 8) Separate and identify sugar present in honey by paper chromatography.
- 10) To check up by TLC technique whether the following ink consist of single or multiple mixtures of dyes.

#### Part-B:

- 1) Determination of pK value of acid-base indicator (methyl red, methylene blue & bromo cresol) by spectrophotometrically.
- 2) Determination of standard electrode potential of Zinc and Copper.
- 3) To find the strength of HCl and Acetic acid in given mixture potentiometrically.
- 4) To find the strength of mixture of halides by titrating it against  $\text{AgNO}_3$  solution potentiometrically.
- 5) To determine the hydrolysis constant of aniline chloride by emf method.
- 6) To determine the solubility and solubility product of a sparingly soluble salt potentiometrically.

- 7) To determine the heat of reaction, equilibrium constant and other thermodynamic functions for the reaction  $\text{Zn} + \text{Cu}^{2+} = \text{Zn}^{2+} + \text{Cu}$  potentiometrically.
- 8) To titrate ferrous ammonium sulphate solution with potassium dichromate solution potentiometrically using bimetallic electrode pair.
- 9) To determine the dipole moment of given liquid.
- 10) To obtain the phase diagram of ethanol-water-benzene system at room temperature.
- 11) To obtain solubility curve for liquid say water-acetic acid-chloroform system.
- 12) Determination of strength of commercial phosphoric acid/Vinegar by conductometric analysis.

#### Physical Chemistry Practical

#### Books Suggested :

- 1) Experimental physical chemistry, R.C. Das and B. Behera, Tata McGraw-Hill
- 2) Advanced physical chemistry J.B. yadao, Goel Pub House
- 3) Experiments in physical Chemistry, D.P. Shormaker, C.W. Garland and J.W. Nibler, Tata McGraw Hill Comp.
- 4) Post graduate physical chemistry, Patel, Turakhia, Kelkar, Himalaya Pub House
- 5) Experiments, in physical chemistry, D.v. Jahagirdar, Himalaya Pub House
- 6) Practical Physical Chemistry, A. Findlay Revised by J.A. Kitehner, Longmans , Green
- 7) Experiments in Physical Chemistry, F. Daniels and J. Williams, Mc Graw Hill.
- 8) Systematic Experimental Physical Chemistry, T.K. Chondekar & S.W. Rajbhoj, Anjali Pub. Aurangabad.
- 9) Advanced Physical Chemistry Experiments, J.N. Gurtu & A. Gurtu, Pragati Prakashan
- 10) Practical Physical Chemistry, A.M. James & P.E. Prichard, Longam Group Ltd.
- 11) Experiments in physical Chemistry, J.M.Wilson, K.J.Newcombe, A.R. Denko, and R.M.W.Richett, Pergamon Press,
- 12) Senior Practical Physical Chemistry, B.D.Khosle and V.S. Garg S.Chand & Comp.

**Practical-III**  
**Physical Chemistry**

|                                       |             |
|---------------------------------------|-------------|
| Time : 6-8 Hrs. (One day Examination) | Marks : 100 |
| (1) Exercise-1 (Based on Part-A)      | - 40 Marks  |
| (2) Exercise-2 (Based on Part-B)      | - 40 Marks  |
| (3) Record                            | - 10 Marks  |
| (4) Viva-Voce                         | - 10 Marks  |

**Semester II**  
**Practical IV**  
**Inorganic Chemistry Practicals**

|  |          |
|--|----------|
| Practical Work load 9 Hrs. /Week   | Marks 50 |
| I] Preparation of inorganic compounds and their characterization by elemental analysis, MW determination, decomposition temperatures and molar conductance studies. (Minimum 6)  |          |
| 1. [VO (acac) <sub>2</sub> ]   |          |
| 2. <i>Cis</i> K [Cr (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> (H <sub>2</sub> O) <sub>2</sub> ]  |          |
| 3. Na [Cr (NH <sub>3</sub> ) <sub>2</sub> (SCN) <sub>4</sub> ]   |          |
| 4. Mn (acac) <sub>3</sub>  |          |
| 5. K <sub>3</sub> [Fe (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> ]  |          |
| 6. Hg [Co (SCN) <sub>4</sub> ]   |          |
| 7. [Co (Py) <sub>2</sub> Cl <sub>2</sub> ]   |          |
| 8. TiO (C <sub>9</sub> H <sub>8</sub> NO) <sub>2</sub> (H <sub>2</sub> O) <sub>2</sub>   |          |
| 9. <i>Cis</i> [Co (trine)(NO <sub>2</sub> ) <sub>2</sub> ] Cl H <sub>2</sub> O   |          |
| 10. [Cu <sub>2</sub> (CH <sub>3</sub> COO) <sub>4</sub> (H <sub>2</sub> O) <sub>2</sub> ]  |          |
| 11. K <sub>3</sub> [Al (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> ](H <sub>2</sub> O) <sub>3</sub>  |          |
| 12. Ni (dmg) <sub>2</sub>  |          |
| II] A) Quantitative Analysis of mixture of two cations:<br>Quantitative analysis of binary mixture of cations involving their chemical separation and separate analysis of one cation by gravimetry and another by volumetric or colorimetric. Certain model examples are given below:                 |          |
| i) Copper (II) and Nickel (II)   |          |
| ii) Copper (II) and Zinc (II)  |          |
| iii) Nickel (II) & Zinc (II)   |          |
| iv) Copper (II) & Iron (III)   |          |
| B) Analysis of Limestone, Dolomite and Bauxite.  |          |
| III] Qualitative analysis of radicals<br>Qualitative analysis of inorganic mixture for a total of five radicals including interfering radicals (not more than one such radical in a mixture), rare earth (not more than two rare earths in a mixture) and combination of cations (minimum 8 mixtures). |          |

Cations: Mercury (I, II), Pb, Ag, Bi (III), Cu (II), Cd (II), As (IV, V), Sb (IV, V), Sn (II, IV), Fe (III), Al (III), Cr (III), Ni (II), Co (II), Mn (II), Zn (II), Barium, Strontium, Calcium and Magnesium.

Interfering radicals: Phosphate, Oxalate, Fluoride and Borate.

Rare Earth: Tl, Mo, W, Se, Ti, Zr, Th, V, U, Ce.

**The Practical examination will be based on the Inorganic Chemistry.**

|                                       |             |
|---------------------------------------|-------------|
| Time: 6-8 hours (one day examination) | Marks: 100  |
| I) Exercise -1 (Synthesis/Radicals)   | - 40 Marks  |
| II) Exercise-2 (Estimation)           | - 40 Marks  |
| III) Record                           | - 10 Marks  |
| IV) Viva- Voce                        | - 10 Marks  |
| <hr/>                                 |             |
| Total                                 | - 100 Marks |

**List of Books-**

1. Synthesis and Characterization of Inorganic Compounds, W. L. Jolly, Prentice Hall.
2. Inorganic Experiments, J. Derck Woollins, VCH.
3. Practical Inorganic Chemistry, G. Mairand, B. W. Rockett, Van Nostrand.
4. A Text Book of Quantitative Inorganic Analysis, A. I. Vogel
5. EDTA Titrations. F. Laschka
6. Instrumental Methods of Analysis, Willard, Merit and Dean (CBS, Delhi).
7. Inorganic Synthesis, Jolly
8. Instrumental Methods of Chemical Analysis, Yelri Lalikov
9. Fundamental of Analytical Chemistry, Skoog D.A. & West D.M Holt Rinehart & Winston Inc.
10. Experimental Inorganic Chemistry, W.G.Palmer, Cambridge.

**Syllabus for Semester III**

**Paper IX**

**Spectroscopy I**

60 Hours (Four hours/week)      12 Hrs. / Unit.      Max.Marks.50.

**Unit-I**

- A) Unifying principle: Electromagnetic radiation, interaction of electromagnetic radiation with matter- absorbance emission, transmission, reflection, refraction, dispersion, polarization and scattering. Uncertainty relation and natural line width and line broadening, transition probabilities, results of the dependent perturbation theory, transition moment, selection rule, intensity of spectral lines. Born-oppenheimer approximate, rotational, vibrational and electronic energy level.

B) Microwave spectroscopy: Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non rigid rotor, Stark effect, nuclear and electron spin interaction and effect of external field, applications. 6L

**Unit-II** A) Ultraviolet and visible spectroscopy : Various electronic transition (185-800nm), Beer-Lambert law, effect of solvent on electronic transition, UV band for carbonyl compounds, unsaturated carbonyl compound, diene, conjugated polyenes. Fisher-Woodward rules for conjugated dienes and carbonyl compounds, UV spectra of aromatic and heterocyclic compounds. Steric effects in biphenyls. 4L

B) Infrared spectroscopy : Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strength, anharmonicity, Morse potential energy diagram, vibration of polyatomic molecules, selection rules, normal modes of vibration, group frequencies, overtone band, factors affecting the band position and intensities, far IR region, metal ligand vibrations, Instrumentation and sample handling characteristics. Vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, amines. Detail study of vibrational frequencies of carbonyl compounds, (ketones, aldehydes, esters, amides, acids, acid chlorides and anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent on vibrational frequencies, overtones, combination bands and Fermi resonance. FT-IR, IR of gaseous solids and polyatomic materials. Modes of bonding of ambidentate ligands etc. 8L

**Unit-III** : Mass spectrometry: Introduction, theory, measurement techniques (EI, CI, FD, FAB) recording of mass spectrum. types of ions, isotopic contribution, fragmentation process, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds of various types, common functional groups, molecular ion, metastable ions, McLafferty rearrangement. Retro-Diels Alder fragmentation, nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structural determination. 12L

**Unit-IV** Nuclear Magnetic Resonance Spectroscopy: General introduction and definition of nuclear spin, nuclear resonance shielding of magnetic nuclei, chemical shift, factors influencing chemical shift, deshielding, chemical shift values and correlation for protons bonded to carbons (aliphatic, olefinic, aldehydic, aromatic) and other nuclei. (alcohols, phenols, enols, acids, amides, and mercaptans), chemical exchange, effect of deuteration, spin spin coupling (n+1) rule, complex spin spin interaction between two, three, four, and five nuclei (first order spectra) factors affecting coupling constant  $\delta J$  classification of spin system like AX, AX<sub>2</sub>, ABX, AMX, ABC, A<sub>2</sub>B<sub>2</sub> etc. Spin decoupling, basic idea about instrument, mechanics of measurement, Stereochemistry, hindered rotation. 12L

**Unit-V** A) Karplus curve-variation of  $\delta J$  with dihedral angle. Simplification of complex spectra, nuclear magnetic double resonance, contact shift reagent, solvent effects, Fourier transform technique, nuclear Overhauser effect (NOE). Resonance of other nuclei like P, F. Some application including biochemical system, an overview of NMR of metal nuclei with emphasis on <sup>195</sup>Pt and <sup>119</sup>Sn NMR. 6L

B) Carbon : <sup>13</sup>C NMR spectroscopy : General consideration, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl), coupling constants, general idea about two dimensional NMR spectroscopy  $\delta$  COSY, NOESY- DEPT techniques, solid state NMR. 6L

#### Books suggested

- 1) Spectroscopic identification of organic compound-RM Silverstein, GC Bassler and TC Morrill, John Wiley
- 2) Introduction to NMR spectroscopy-RJ Abraham, J Fisher and Ploftus Wiely
- 3) Application of spectroscopy to organic compound-JR Dyer, Printice Hall
- 4) Organic spectroscopy-William Kemp, ELB with McMillan
- 5) Spectroscopy of organic molecule-PS Kalsi, Wiley, Esterna, New Delhi
- 6) Organic spectroscopy-RT Morrison, and RN Boyd
- 7) Practical NMR spectroscopy-ML Martin, JJ Delpenck, and DJ Martyin
- 8) Spectroscopic methods in organic chemistry-DH Willson, I Fleming
- 9) Fundamentals of molecular spectroscopy-CN Banwell
- 10) Spectroscopy in organic chemistry-CNR Rao and JR Ferraro
- 11) Photoelectron spectroscopy-Baber and Betteridge



- 12) Electron spin resonance spectroscopy-J Wertz and JR Bolten
- 13) NMR δBasic principle and application-H Guntur
- 14) Interpretation of NMR spectra-Roy H Bible
- 15) Interpretation of IR spectra-NB Coulthop
- 16) Electron spin resonance theory and applications-W gordy
- 17) - Mass spectrometry organic chemical applications ,JH Banyon

### Semester III

#### Paper X

#### Analytical Chemistry-I

#### Thermal & Electroanalytical Methods

Total Lectures: 60Hours, 4Hours per week, 12Hours/unit Total Marks: 50

- Unit-I : Thermal methods of Analysis: 12L**  
 Introduction of different thermal methods, Thermogravimetry TG and DTG, Static thermogravimetry, quasistatic Thermogravimetry and dynamic thermogravimetry, Instrumentation, Factors affecting thermograms, Applications of thermogravimetry, Differential thermal analysis (DTA), DTA curves, Factors affecting DTA curves, instrumentation, applications of DTA. Simple numerical problems.  
 Differential Scanning Colorimetry(DSC): Introduction, Instrumentation, DSC-curves, factors affecting DSC curves and applications. Thermometric Titrations; Introduction, apparatus, theory and applications.
- Unit-II : Electroanalytical Methods 12L**  
 Conductometry: Principal of analysis, measurement of conductance, analytical applications of conductometry, conductometric titrations. High frequency titrations. Types of cells used, instrumentation and applications. Problems. Electrogravimery: Theory of electrolysis, electrode reactions, over voltage, characteristics of deposits and completion of deposition, separation of metals.  
 Coulometry: Principal, coulometry at constant potential, coulometry at constant current, coulometric method of analysis, instrumentation, coulometric titrations. Advantages of coulometric titrations. Applications of coulometric titrations

- Unit-III : Electroanalytical Techniques 12L**  
 Potentiometry & pH Metry: Potentiometry, Indicator electrodes: hydrogen electrode, quinhydrone electrode, antimony electrode and glass electrode, Reference electrodes, Bimetallic electrode, Theory of potentiometric titrations, Problems, Nernst equation, standard electrode potential, Determination of cell potential, n, Kf and Ksp. pH titrations. Ion Selective Electrodes: Terminology, types and construction of ion selective electrodes. Electrical properties of membrane, Glass membrane electrodes, solid-state sensors, gas sensing and enzyme electrodes. Glass electrode with special reference to H<sup>+</sup>, Na<sup>+</sup>, K<sup>+</sup> ions, interference, ion activity evaluation methods, operations of solid membrane electrode, operation of liquid membrane electrode, coated type ion electrode. Applications of ion selective electrode in determination of some toxic metals and some anions (F<sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup> and NO<sub>3</sub><sup>-</sup>). Advantages of ISEs.
- Unit-IV : Electroanalytical Techniques: 12L**  
 Polarography : Basics of polarography, reference and working electrodes, operational amplifiers concepts, components of the limiting current, adsorption, kinetic, catalytic and diffusion currents and to distinguish them. Dropping mercury electrode, Ilkovic equation-diffusion current constant and capillary characteristics determination. Half wave potential, Polarographic maxima. Role of temperature on diffusion current. Reversible, quasi reversible and irreversible electrode reactions and evaluation of parameters using various reactions. Organic polarographic analysis. Limitations of polarography, advancements-pulse and differential pulse polarography.
- Unit-V : Electroanalytical Techniques 12L**  
 Voltammetry & amperometric: Linear and Cyclic sweep voltammetry. Randleø Sevcik equation. Adsorption complications in voltammetry. Tests for electrode reactions coupled with chemical reactions, EC and ECE reactions. Application of voltammetry in the study of unstable reaction intermediates. Enzyme catalyzed reactions and applications of voltammetry in monitoring such reactions.  
 Stripping Technique: Anodic and cathodic stripping voltammetry and their applications in the trace determination of metal ions and biologically important compounds. Principal, methodology and applications amperometric titrations. Chronopotentiometry.

**List of Books-**

1. Day and Underwood: Quantitative Analysis
2. A. I. Vogel: A text book of quantitative analysis.
3. Flaschka: EDTA Titration
4. Meites and Thomas: Advanced Analytical Chemistry.
5. G. W. Ewing: Instrumental Methods of Chemical Analysis.
6. R. S. Draga: Physical Methods in Inorganic Chemistry
7. G. D. Christian: Analytical Chemistry
8. S. M. Khopkar: Basic Concept of Analytical Chemistry.
9. Kolltath and Ligane: Polarography
10. Braun: Instrumental Methods of Chemical Analysis
11. Willard, Merritt and Dean: Instrumental Methods of Analysis
12. Strouts, Crifillan and Wison: Analytical Chemistry.
13. J. W. T. Spinks and R. J. Woods: Introduction to Radiation Chemistry.
14. S. A. Skoog and D. W. West: Fundamental Of Analytical Chemistry
15. R. V. Dilts: Analytical Chemistry

**Semester III****Paper XI****Special Paper-I****Inorganic Chemistry (Bio-inorganic Chemistry)**

Total Lectures: 60Hrs, 4 Hrs per week, 12 Hrs/unit      Total Marks-50

**Unit-I****12L**

- A) Essential and trace metals in biological systems:** Biological functions of inorganic elements, biological ligands for metal ions. Coordination by proteins, Tetrapyrrole ligands and other macrocycle. Influence of excess and deficiency of V, Cr, Mn, Fe, Co, Cu, & Zn. Genetic defects in the absorption of trace elements. Regulation and storage of trace elements. Role of minerals. Toxic effects of metals.
- B) Metal storage, transport and biomineralization with respect to Ferritin, Transferrin and Siderophores, Na<sup>+</sup>/K<sup>+</sup> pump. Role of Ca in transport and regulation in living cells**

**Unit-II****12L**

Medicinal use of metal complexes as antibacterial, anticancer, use of cis-platin as antitumor drug, antibiotics & related compounds. Metal used for diagnosis and chemotherapy with particular reference to anti cancer drugs. Chelate therapy, chemotherapy with compounds of some non essential elements; platinum complexes in cancer therapy. Antiviral activity of metal complexes. Gold containing drugs used in the therapy of Rheumatic-Arthritis, Gold complexes as anticancer drug. Lithium in psycho pharmacological drugs. Antimicrobial agents.

**Unit-III****12L**

- A) Bio-energetics and ATP cycle:** DNA polymerization, metal complexes in transmission of energy, chlorophylls, photosystem I and photosystem II in cleavage of water, Model systems.
- B) Electron transfer in Biology:** Structure and functions of metalloproteins in electron transfer proteins, cytochromes & Fe-S proteins, Non-heme iron proteins; Rubredoxins, Synthetic models. Biological Nitrogen fixation (in vitro and in vivo)

**Unit IV****12L**

**Transport & Storage of Dioxygen:** Heme proteins & oxygen uptake, structure and functions of haemoglobin, myoglobin, hemocyanins & hemerythrin. Perutz mechanism showing structural changes in porphyrin ring system. Oxygenation and deoxygenation. Model compounds. Cyanide poisoning and treatment. Vanadium storage and transport.

**Unit-V****12L**

**Metallo enzymes:** Apoenzymes, Haloenzyme & Coenzyme. The principle involved and role of various metals in-

- i) Zn-enzyme:- Carboxyl peptidase & Carbonic anhydrase.
- ii) Fe-enzyme:-Catalase Peroxidase & Cytochrome P-450
- iii) Cu-enzyme:-Super Oxide dismutase
- iv) Molybdenum:-Oxatransferase enzymes, Xanthine oxidase,Co-enzyme

Vit. B<sub>12</sub>, Structure of vitamin B<sub>12</sub> Co-C bond cleavage, Mutase activity of co- Enzyme B-12, Alkylation reactions of Methyl Cobalamin. Synthetic model of enzyme action, stability and ageing of enzyme.

**Books:**

1. Akhmetov, N.: General and Inorganic Chemistry.
2. Aylett, B. and Smith, B.: Problems in Inorganic Chemistry, (English University Press)
3. Bertini, et al: Bioinorganic Chemistry (Viva)
4. Charlot, G and Bezier, D.: Quantitative Inorganic Analysis (John Wiley).
5. Douglas, B. E. McDaniel, D. H. et al: Concept and Models of Inorganic Chemistry (4<sup>th</sup> ed.) J. Wiley
6. Dutt P. K.: General and Inorganic Chemistry.(Sarat Books House)
7. Fenton, David E.: Biocoordination chemistry, Oxford
8. Jolly, W. L. : Inorganic Chemistry (4<sup>th</sup> edn.) Addison-Wesley.
9. Katakis, D. and Gordon, G: Mechanism of Inorganic Reactions.(J. Wiley).

10. Leigh, G. J.: IUPAC Nomenclature of Inorganic Chemistry (1990;Jain-Interscience)
11. Massey, A. G.: Main Group Chemistry.
12. Porterfield, W. W.: Inorganic Chemistry-A unified approach (Holt Saunders)
13. Banerjee,D.:Coordination Chemistry,TMH
14. Lee J.D.:Concise Inorganic Chemistry,ELBS
15. Lippard S.J and Berg,J.M.: Principal of Bioinorganic Chemistry,University Sci.Book.,Mill Valley
16. Hay R.W.:Bioinorganic Chemistry, Ellis Horwood, Chichester and NY
17. Das A.K.: Text Book of Medicinal Aspects of Bioinorganic Chemistry,CBS
18. Sigel H.:Metal ions in Biological systems,Marcell Dekker,NY(Vol. I-31)
19. Reddy K.H.,Bioinorganic Chemistry,New Age Int.Pub.
20. Kaim W.and Schwederski B.:Bioinorganic Chemistry:Inorganic elements in the Chemistry of Life,JohnWiley & Sons.
21. Medicinal Inorganic Chemistry, Edited by Jonathan L.Sessler, Oxford University Press.

### Semester III

#### Paper XII

#### Special Paper-II

#### Inorganic Chemistry (Solid State Chemistry)

Total Lectures:60 Hours,4Hours/week, 12Hours/unit Total Marks-50

**Unit-I :** **12L**

#### Crystal Structure of Some Simple Compounds:

- i) Ionic Crystals & Their structures, radius ratio rule, effect of polarization on crystals.
- ii) Covalent structure type-Diamond, Sphalerite & Wurtzite.
- iii) Geometry of simple crystal AB type: NaCl, CsCl & NiAs & Wurtzite, reasons for preference for a particular structure in above AB type of compounds.
- iv)  $AB_2$  type: Fluorite, antiferrofluorites, Rutile structures.  $Li_2O$ ,  $Na_2O$ , etc.  $CdCl_2$ ,  $CdI_2$  structures, difference between them.  $AB_2$  type:  $ReO_3$ ,  $BiI_3$ ,  $CrCl_3$ ,  $A_2B_3$  type:  $Fe_2O_3$ , Corundum  $Al_2O_3$ ,  $Mn_2O_3$ .
- v) Ternary Compounds  $ABO_3$  type: Perovskite, Barium titanate, lead titanate,  $CaTiO_3$  Tolerance factor, charge neutrality & deviation structures.  $FeTiO_3$ .

- vi)  $AB_2O_4$  type- Spinel, Normal & inverse, 2-3 and 4-2 spinel, packing of oxygen in tetrahedral & octahedral sites, sites occupancy number of site surrounding each oxygen, application of charge neutrality principles, site preferences in spinel, distorted spinel. Hausmannite (Jahn-Teller distortions), Factors causing distortion in spinel.

**Unit-II:** **12L**

**Lattice Defects:** Perfect & Imperfect crystals, point defects, Interstitial, Schottky defect, Frenkel defect, line defect & other entities, thermodynamics of Schottky & Frankel defects. Dissociation, theory of dislocation, plane defects- Lineage boundary, grain boundary, stacking fault, 3D defects, Defects & their concentrations, ionic conductivity in solids, Non stoichiometric compounds. Electronic properties of Non-stoichiometric oxides, solid electrolytes, pyknetric & electrical conductivity methods of study of defects, radiation effects on solid nature and properties, photography, colour centers, order-disorder changes, defects, imperfection equilibrium, atom movements, and defect interactions.

**Unit-III :** **12L**

**Electronic Properties of materials:** Metals, Insulators & semiconductors, electronic structure of solid: band theory, band structure of metals, insulators & semiconductors. Intrinsic & extrinsic semiconductors, doping semiconductors. Seebeck effect and Hall effect. Organic semiconductors, properties & their applications. Types of ionic conductors, mechanism of ionic conduction, diffusion, superionic conductors, phase-transitions & mechanism of conduction in super ionic conductors, applications of ionic conductors.

**Unit-IV :** **12L**

**Dielectric polarization:** Piezo-electricity, pyroelectricity, ferrielectricity, antiferroelectricity, ferroelectricity & their applications.

**Superconductivity:** Introduction, discovery magnetic properties of super conductor, theory of super conductivity, Meissner effect, type I&II superconductors, Josephson effects, Hc- temperature superconductor, crystal structure of high temperature semiconductors, & its uses.

Lasers and Masers actions, laser production and applications

**Unit-V :** **12L**  
**Magnetic Properties of Materials:** Introduction, Magnetization, Electronic Spin and Magnetic Moment, Classification of materials, magnetic susceptibility, paramagnetism in metal complexes, diamagnetism, ferromagnetic metals, ferromagnetic compounds ( $\text{CrO}_2$ ), Antiferromagnetism- transition metal monoxides, ferrimagnetism (ferrites), magnetic anisotropy, magnetostriction, cooperative phenomena- magnetic domains, Domain Theory, hysteresis loops (hard & soft magnets) magnetic storage & applications of magnetic materials. Spin glasses.

**Books:**

1. Azaroff L. V., Introduction to Solids, TMH
2. West A. R., Solid State Chemistry and its Applications, Plenum
3. Rao C. N. R., Solid State chemistry, Dekkar
4. Hagenmuller, Preparative methods in solid state chemistry
5. Keer H. V., Principles of the Solid state, Wiley Eastern.
6. Hannay N. B., Solid State Chemistry
7. Chakrabarty D. K., Solid State Chemistry, New Age Int.
8. West A. R., Solid state Chemistry, John Wiley
9. Pillai S. O., Solid state Physics, Academic press
10. Rey T. J., The Defects Solid state, Interscience
11. Azoroff L. V. Brophy J. J., Electronic Process in Materials, McGraw Hills
12. Anderson and Leaver, Materials Science
13. Kirkendall, Analytical Methods of Materials Investigations
14. Greenwood N. N. Ionic Crystals, Lattice Defects and Nonstoichiometry, Butter worth
15. Kroger Chemistry of imperfect crystals, Holland
16. Callister W. D. Jr., Material Science and Engineering An Introduction, Wiley India
17. Van Bueren H. G., Imperfection in Crystals, Wiley-Interscience
18. Brandon D and Kaplan W. D. Microstructural Characterization of Materials, Wiley NY.
19. Hummel R. E. Electronic Properties of Materials, Springer-Verlag
20. Solymar L. and Walsh D., Electrical properties of Materials, Oxford University Press
21. Jiles D., Introduction to Magnetism and Magnetic Materials, Nelson Thornes, Cheltenham
22. Kotz J. C., and Treichel, P. Jr. Chemistry AND chemical Reactivity, Saunders

23. Masterton W. L. and Hurley C. N. chemistry, Principles and Reactions, Harcourt

**SEMESTER III**

**Paper XI**

**Special Paper-I**

**Organic Chemistry (Organic Synthesis-I)**

**Total Lectures: 60 Hrs, 4 Hrs per week, 12 Hrs/unit Total Marks-50**

**Unit-I : Photochemistry.**

Interaction of radiation with matter, types of excitation, rate of excited molecules, quenching, Quantum efficiency, quantum yield, transfer of excitation energy, actinometry, singlet and triplet states, experimental methods in photochemistry of carbonyl compounds, and transition, Norrish type I and Norrish type II reactions Paterno-Büchi reaction, Photoreduction, Photochemistry of enones, Hydrogen abstraction rearrangement of unsaturated ketones and cyclohexadienones, Photochemistry of parabenzoquinones, photochemistry of Aromatic compounds with reference to isomerisation addition and substitution Photochemical isomerization of cis and trans alkenes, Photochemical cyclization of reaction, Photo-Fries rearrangement, Photo theory reaction of anilides 12L

**Unit-II : Pericyclic Reactions**

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene, allyl system, classification of pericyclic reaction. FMO approach, Woodward-Hoffman correlation diagram method and Perturbation of molecular orbital (PMO) approach of pericyclic reaction under photochemical conditions. Electrocyclic reactions, conrotatory and disrotatory motion  $4n$  and  $(4n+2)$  systems, with more emphasis on  $(2+2)$  and  $(4n+2)$

Cycloaddition of ketones Secondary effects in  $(4+2)$  cycloaddition. Stereochemical effects and effect of substituents on rate of cycloaddition reaction, 1,3-dipolar-cycloaddition and chelotropic reaction. Sigmatropic rearrangement, suprafacial, and antarafacial shift involving carbon moieties, retention and inversion of configuration,  $(3,3)$  and  $(3,5)$  sigmatropic rearrangements, Claisen and Cope rearrangements. 12L

**Unit-III: A) Oxidation-Reduction and Electron transfer reactions**

- I) Oxidation: Principle, aromatisation, dehydration yielding C=C, oxidation aldehyde, ketone, cleavage of C-C single bond in glycols, ozonolysis, epoxidation, Oppenauer oxidation, Sommelet reduction.
- II) Reduction: Selectivity in reduction, reduction of nitro and nitroso compounds, metal hydride reduction, dissolving metal reduction, reduction of aldehydes, ketones to alcohols, reduction of carbonyl group to methylene.
- III) Electron transfer reaction: Selective oxidation of alkyl side chain in aromatic compounds, alcohols and acid using Co(III), Reduction with  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ .

12L

**Unit-IV: A) Formation of C-C bond**

Principle, disconnection, synthons, electrophilic and nucleophilic carbon species, use of following reaction in carbon carbon bond formation, base catalysed condensation, Aldol, Claisen, Perkin, Stobbes, Knoevenagel use of malonic and acetoacetic esters. Michael addition. Wittig reaction, use of acetylides, acid catalysed condensation of olefins, FC reaction, Fries reaction and Diels Alder reaction.

12L

- Unit-V: A) Umpolung concept:** Dipole inversion, generation of acyl anion, use of 1,3-dithiane, methylthiomethylsulphoxide bis(phenylthiomethane). Metallated enol ethers, alkylidene dithiane, ketone thioacetals, 2-propenethiobismethyl thioallyl anion.
- B) Phosphorus and sulphur ylides:** Preparation and their synthetic application along with stereochemistry. Enamines: Chemistry of enamines and their synthetic applications.

12L

**Books suggested.**

- 1) Principle of organic synthesis. R.C. Norman & J.M. Coxon
- 2) Modern synthetic reaction. H.O. House W.A. Benjamin
- 3) Organic synthesis, The disconnection approach-S. Warren
- 4) Designing organic synthesis-S. Warren
- 5) Some modern methods of organic synthesis-W. Carruthers,
- 6) Advance organic reaction. Mechanism & structure-Jerry March
- 7) Advance organic chemistry Part-B-F.A. Carey & R.J. Sundberg, Plenum P.
- 8) Organic reaction and their mechanism-PS Kalsi
- 9) Protective group in organic synthesis-TW Greene, & PGM
- 10) The chemistry of organophosphorous-AJ Kirby, & SG Warren
- 11) Organosilicon compound-C. Eabon

- 12) Organic synthesis via Boranes-HC. Brown
- 13) Organoborane chemistry-TP Onak
- 14) Organic chemistry of boron-W. Gerrard
- 15) Fundamentals of photochemistry-KK Rohatgi & Mukharji
- 16) Photochemistry-Cundau & Gilbert
- 17) Aspects of organic photochemistry-WM Horspool
- 18) Photochemistry-JD Calvert
- 19) Photochemistry-RP Wayne

**Semester-III****Paper XII****Special Paper-II****Organic Chemistry (Natural Product-I)****Unit-I : Carbohydrates**

Types of naturally occurring sugars, deoxy sugars, amino sugars, branched chain sugars, methyl ethers and acid derivatives of sugars, general methods of structure and ring size determination with reference to maltose, lactose, sucrose, starch and cellulose.

12L

**Unit-II : A) Amino acids, protein and peptides.**

Amino acids, structural characteristics, acid base property, stereochemistry of amino acids, optical resolution, Stecker synthesis, peptide and proteins. Structure of peptide and protein, primary, secondary, tertiary and quaternary structure. Reaction of polypeptide, structure determination of polypeptide, end group analysis, purines and nucleic acids, chemistry, structure and functional relation to gene of DNA and RNA.

8L

- B) Prostaglandins:** Occurrence, nomenclature, classification and physiological effects, synthesis of PGE<sub>2</sub> and PGE<sub>2a</sub>

4L

**Unit-III :** Classification, Isolation, General Methods of structure determination of the following 12L

- A) Alkaloids:** Papaverine, Morphine, Reserpine, Nicotine.  
**B) Terpenoids:** Camphor, Geraniol, Abietic acid, squalene

**Unit-IV: A) Steroids and Hormones** 12L

Cholesterol, Testosterone, Progesterone and Cortisone  
**B) Biosynthesis of Natural Products.**  
 Biosynthesis of terpenes, alkaloids, and amino acids (Lysine and phenylalanine)

**Unit-V: DYES**

- A) Dyes:** General Introduction, classification on the basis of

structure and method of application dyeing mechanism, methods of dyeing, such as direct dyeing, vat dyeing, dispersive dyeing, formation of dye in fibre, dyeing with reactive dyes, study of quinoline yellow, cyamine dye, ethyl red, methylene blue, Alizarin, cyamine-green, fluorescein, eosin, erythrosine, Rhodomines and Indigo.

**Books suggested :**

- 1) Chemistry of alkaloids-SW Pelletier.
- 2) Chemistry of steroids-LF fisher & M fisher.
- 3) The molecules of nature-JB hendricson.
- 4) Biogenesis of natural compound-benfield
- 5) Natural product chemistry & biological significance, J.Mann, RS devison, JB hobbs, DV Banthripde & JB horborne.
- 6) Introduction to flavonoids-BA Bohm, Harwood
- 7) Chemistry of naturally occurring quinines-RH Thomson
- 8) The systematic identification of flavonoids-marby, markham, & thomos
- 9) Text book of organic medicinal chemistry-wilson, geswold
- 10) Medicinal chemistry Vol I & II-Burger
- 11) Synthetic organic chemistry-Gurudeep chatwal.
- 12) Organic chemistry of natural products Vol I & II-OP agrawal
- 13) Organic chemistry of natural products-Gurudeep chatwal
- 14) A textbook of pharmaceutical chemistry-Jayshree Ghosh
- 15) Synthetic dyes series-venkatraman
- 16) Chemistry process industries-shreve & brink
- 17) Principal of modern heterocyclic chemistry-LA paquelte
- 18) Heterocyclic chemistry-J Joule & G smith
- 19) Heterocyclic chemistry-morton
- 20) An introduction to chemistry of heterocyclic compound-JB acheson
- 21) Introduction to medicinal chemistry-A gringuadge
- 22) Wilson & Gisvold text book of organic medicinal & pharmaceutical chemistry-Ed. Robert F dorge
- 23) An introduction to drug design-SS pandey, & JR demmock
- 24) Goodman and Gilman's pharmacological basis of therapeutics-
- 25) Strategies for organic drug synthesis & design-D lednicer
- 26) Polymer science-v govarikar
- 27) Principle of polymer chemistry-PJ flory
- 28) An outline of polymer chemistry-james q.allen
- 29) Organic polymer chemistry-KJ Saunders.

**Semester III**  
**Paper- XI**  
**(Special Paper-I)**  
**Physical Chemistry**

60 Hours (4-Hours/week)

50 Marks

12 hours/Unit

**Unit-I Solid-state chemistry:**

- A) Solid state reactions: General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, other precursor methods, kinetics of solid state reactions. 6L
- B) Crystal Defects & Non-Stoichiometry: Intrinsic and extrinsic defects- point defects, line and plane defects, vacancies-Schotky defects and Frenkel defects. Thermodynamics of Schotky and Frenkel defect formation, color centers. Non-Stoichiometry and defects. Numericals. 6L

**Unit-II Electronic properties and Band Theory:**

- A) Metals, insulators and semiconductors, electronic structure of solids- band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, semiconductor p-n junctions. Color in inorganic solids, 6L
- B) Magnetic properties- Behavior of substances in magnetic field. Effect of temperature: Curie and Curie-Weiss Laws. Calculation of magnetic moments, magnetic materials, their structures and properties. Applications: structure / property relations. Numericals. 6L

**Unit-III Glass, Ceramics and Multiphase materials:**

- A) Factors influencing glass formation, kinetics and thermodynamics of glass formation, electrical (ionic) Conductivity of glasses, metallic glasses. Composition, properties and applications of glass-ceramics. 6L
- B) Properties and applications of ferrous and non-ferrous alloys. Phase diagram of iron-carbon system. Stainless steel, brass. 6L

**Unit-IV Ceramics and Composites:**

- A) Structure and properties of ceramic: Crystal structure, silicate ceramics, carbon, and imperfection in ceramic, diffusion in ionic materials, ceramic phase diagram. Type and application of ceramics, Glasses and glass ceramics clay product refractories, abrasive, cement and advanced ceramics, fabrication and processing of ceramics, fabrication and processing of glass and clay product, powder processing and tape casting. 6L

- B) Particle reinforced Composites: Large particle and dispersion-strengthened Composites, Fiber reinforced Composites: Influence of fiber length, fiber orientation and concentration. Metal- Matrix Composites, Ceramics- Matrix Composites, Carbon-Carbon and hybrid Composites.

6L

**Unit-V Superconductivity:**

- A) High T<sub>c</sub> Materials: Superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials. Normal and Superconducting state of cuprates. The BCS theory. Applications of Low-temperature and High-temperature Superconductors. 6L
- B) Thin Films: Preparation techniques: evaporation/sputtering, chemical processes, MOCVD, sol-gel etc. Growth techniques, properties and applications of thin films. 6L

**List of Books:**

- 1) Physical chemistry by P.W. Atkins & dePaula 7<sup>th</sup> Edition
- 2) Industrial Chemistry by B.K. Sharma, Goel Publication House.
- 3) Physical Chemistry of Surface, by A.W. Admson, John Wiley and Sons 1990.
- 4) Electronic structure and Chemistry of Solids by P.A. Cox, Oxford University Press. 1991.
- 5) Solid State Chemistry by D.K. Chakraburti, New Edge International Publication 1996.
- 6) Principles of Solid State by H.V. Kirr, Wiley Eastern Publication.
- 7) Material Science & Engineering an Introduction, by W.D. Callister
- 8) Material Science by J.C. Anderson, K.K. Leaver, J.M. Alexander & R.D. Rawlings. ELBS.

**Semester III****Paper- XII****Special Paper-II****Physical Chemistry**

60 Hours (4-Hours/week)

50 Marks

12 hours/Unit

**Unit-I Polymers:**

- A) Basic concepts: Monomers, repeat unit, degree of polymerization, linear branch, and network polymers, classification polymers, Polymerization: condensation, addition, radical chain ionic and coordination and copolymerisation. polymerization condition and polymer reaction, polymerization in homogeneous and heterogeneous system. 6L

- B) Polymer processing: Plastic, elastomer and fibers. Compounding, processing technique: Calendaring, die casting, rotational casting, film casting, injection molding, glow molding, extrusion molding, thermoforming, foaming, reinforcing and fibers spinning. 6L

**Unit-II Polymer characterization:**

- A) Polydispersion, average molecular weight concept. Number, weight and viscosity average molecular weight. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weight. End group, viscosity, light scattering, osmotic and ultra centrifugation method. 6L
- B) Analysis and testing of polymers: chemical analysis of polymer, X-ray diffraction study, microscopy. Thermal analysis and physical testing-tensile strength. Fatigue impact. Tear resistance. Hardness and abrasion resistance. 6L

**Unit-III Structure and properties of Polymers:**

- A) Morphology and order in crystalline polymers, configuration of polymers chains. Crystal structure of polymers. Morphology of crystalline polymers, strain induced morphology, crystallization and melting. 6L
- B) Properties and structure: Physical properties, crystalline melting point, T<sub>m</sub>-melting point of homogeneous series, effect of chain flexibility and other steric factors. Entropy and heat of fusion, the glass transition temperature, the relation between T<sub>g</sub> and T<sub>m</sub>. Effect of molecular weight, diluents, chemical structures, chain topology, branching and cross linking. Property requirements and polymer utilization. Numericals. 6L

- Unit-IV** A) Polymer composites: Polymer matrix material, reinforcement, properties of composite and composite system. Fabrication of polymer composite, processing science and quality assurance of composites, environmental effect on composites, Smart composites. 6L
- B) Polyethylene, polyvinyl chloride, polyamide, polyester, phenolic resin, epoxy resin and silicon polymer, Functional polymer: electrically conducting polymer. 6L

- Unit-V** A) Polymer degradation: Definition, Types: thermal, mechanical, degradation by ultrasonic waves, photo degradation, degradation by high-energy radiations, oxidative and hydrolytic degradation. 6L

- B) Polymer reactions: Hydrolysis, acetolysis, aminolysis, hydrogenation, addition and substitution reaction, reaction of various specific groups, cyclization reaction and cross linked reactions, reaction leading to graft and block copolymers, miscellaneous reactions. 6L

**List of Books:**

- 1) A Text Book of Polymer Science by Billmeyer, Jr. Wiley
- 2) Polymer Science by V.R.Gowarikar, N. V. Vishwanathan & J. Sreedhar, Wiley Estern.
- 3) Physical Chemistry Polymers by D.D. Deshapande, Tata McGraw Hill
- 4) Principles of Physical Chemistry by P.J.Flory, Cornell University Press
- 5) Introduction to Polymer Chemistry by R.B. Seymour, McGraw Hill.
- 6) A Practical Course in Polymer Chemistry by S.J. Pnnea, Program press.
- 7) Polymer Composite by M.C. Gupta & A.P. Gupta. New Age International Publication.

**Semester III  
Paper XI  
Special Paper-I**

**Industrial Chemistry (Heat Transfer, Unit Operations and Material Balances)**

60hrs (4hrs/week). 12hrs/unit

50 Marks

**Unit-I :** 12L

- A) Fundamentals of Heat transfer:  
Methods of heat transfer, Fourier's law, Newton's law, heat transfer by conductance, by convection and by radiation. Heat exchanger, types of heat exchanger, overall heat transfer co-efficient, double pipe heat exchanger, Shell & tube type etc.
- B) Fluid flow :  
Fluid flow phenomenon, introduction, Laminar flow, Turbulent flow, Reynolds number, Bernoulli's equation, fans, blowers, compressors, pumps etc.

**Unit-II : Unit Operations:** 12L

- A) Distillation: Flash distillation, differential distillation, rectification, plate columns, packed columns.

- B) Gas Absorption : Introduction, equipments, packed columns, spray column mechanically agitated contactors.
- C) Evaporation : Introduction, short tube evaporator, forced circulation evaporator, falling film, climbing film, agitated evaporators.
- D) Filtration : Introduction, Filter media, filter aids, equipments sparkler filter, sand filters, bag filters, rotary drum filter etc. centrifuge.
- E) Crystallisation : Introduction, solubility, supersaturation, nucleation, crystal growth, equipments tank crystallizer, Swenson-Walker crystallizer, Oslo crystallizer.
- F) Drying: Introduction, free moisture, bound moisture, drying curve, equipments: tray dryer, fluid bed dryer, drum dryer

**Unit-III : Material Balances** 12L

Material balance without chemical reactions, flow diagram, without recycle or by-pass for above processes.

Material balances involving chemical reactions, Concept of limiting reactant, conversion, purge operation and energy balance.

**Unit-IV : Catalysis** 12L

Introduction, types, homogeneous & heterogeneous, Basic Principles, mechanism, factors affecting the performance, Introduction to phase transfer catalysis.

Industrial catalysts : Raney nickel, other forms of nickel, palladium and Supported palladium, copper chromate, vanadium & Platinum basecatalyst.

Aluminium alkoxides, titanium tetrachloride & titanates Titanium dioxide & Zeigler Natta catalyst and zeolite Catalysts.

**Unit-V : Materials of construction for chemical plant.** 12L

- A) Metals and Alloys : Copper, Aluminium, Nickel, titanium and their alloys. Mechanical & chemical properties and their applications.
- B) Corrosion : Types of corrosion relevant to chemical industries, mechanism & prevention methods.
- C) Polymeric Materials: Industrial polymer and composite materials, their constitution, chemical and physical properties, industrial applications.

**List of Books-**

- 1) Heat transfer By Arora and Damkondwar, Pune
- 2) Heat and Mass transfer by A, G. Gavane, Nirali Prakashan. Pune VOL I & II



- 3) McCabe and Smith, Unit operations of Chemical Engineering, McGraw Hill.
- 4) Budger and Banchemo, Introduction to Chemical Engineering McGraw Hill. McGraw Hill.
- 5) Text Book of Industrial Chemistry Pragti Agencies Pune 2
- 6) Engineering Chemistry By Dr. S. S. Dara.
- 7) Catalysis in theory and practices, Ridder E. K. and Taylor H. S.
- 8) Phase transfer catalysis, Principles and techniques, Starles C.
- 9) Surface Chemistry by J. J. Bikermann, Academic Press.
- 10) Physical Chemistry of Surfaces, A. W. Aclamson.
- 11) Material science, O. P. Khanna, Khanna Publishers, Delhi

### Semester III

#### Paper XII

#### Sp. Paper-II

### Industrial Chemistry (Processes Economics And Industrial Management)

60hrs (4hrs/week). 12hrs/unit

50 Marks

- Unit-I : Manufacture of Heavy Chemicals 12L**  
 Chemical processes for the manufacture of Heavy chemicals like- soda ash, bicarbonates, chlorine, caustic soda, bleaching power, calcium carbides and acids like  $H_2SO_4$ , HCl,  $HNO_3$ ,  $H_3PO_4$ .
- Unit-II : 12L**
- A) Industrial Gases: Heavy chemicals and production of gases. Chemistry, manufacture, storage, hazards & uses.- Hydrogen, Oxygen, nitrogen, carbon dioxide, chlorine, fluorine,  $SO_2$ , phosgene, acetylene, argon, neon & helium.
  - B) Fertilizers: Fertilizer industries in India, Manufacture of Ammonium salts, Urea, nitrates, Ammonia, Nitrogenous fertilizers, phosphatic fertilizers, superphosphates, complex fertilizers, nitrogen fixation.
- Unit-III: 12L**
- A) Cement: Types of cement, manufacture- processes, and setting of cements.
  - B) Glass: Types, their composition & properties, manufacture of glass fitness, optical glass, coloured glasses, lead glass and neutron absorbing glass.
  - C) Ceramics: Introduction, types, manufacturing process, applications & refractories.
- Unit-IV : Chemical Process Economics 12L**  
 Factors involved in project cost, estimation methods employed for the estimation of capital investment.

Methods of determining depreciation.  
 Competitive & monopoly markets, some aspects of marketing profitability criterion.  
 Economics of selecting alternatives.  
 Break even point, production scheduling

### Unit-V: A) Industrial Management 12L

Concept of scientific management in industry.  
 Functions of management : Decision making, planning, organizing, Material management, Inventory control, Information system & decision making.

### B) Safety :

General occupational safety, flammable materials, Handling, fuel fighting equipments, control measures for Toxic chemicals. Safety with chemical engineering operations, hazardous chemicals process. Safety in Laboratories and pilot plant. Safety in transportation & storage of chemicals, management of safety & loss prevention.

### List of Books-

1. Charles E. Dryden, Outline of Chemical Technology Edited by M. Gopal Rao and Marshall Siting, East West Press 2<sup>nd</sup> Edition 1973.
2. Manual of Chemical Technology VOL I & II by Venkatesharul Educational Development Center. IIT Madras, 1977.
3. Chemical Process Industries by R. N. Shreve and M. J. A. Brink. McGraw Hill Ltd. 4<sup>th</sup> Edition 1977.
4. Economics of chemical industry, Hempel E. M.
5. Industrial organization and management, Bethal L. L.

### Semester III

#### Paper XI

Analytical Chemistry  
 (Advance Separation Techniques)

Total Lectures: 60Hrs, 4Hrsper week, 12Hrs/unit Total Marks-80

### Unit-I : 12L

**Separation Methods:** Filtration, precipitation, distillation, molecular sieve, dialysis, Reverse osmosis, Ring oven methods, relative merit & demerit. Purification Techniques (Solid organic compounds, liquids etc.) Criteria of purity. Theory of chromatography, Classification, principles of chromatography, Van Deemeters Equation, Plate theory, significance of  $E, D_v, D_w$ . Techniques of

chromatographic separation gradient, isocratic, selective specific separation, types of chromatographic methods

**Unit-II :** **12L**

**Gas Chromatography:-**

Introduction to different types of gas chromatography, How does it differ from liquid chromatography. Principles of gas chromatography, plate theory of gas chromatography, Instrumentation for gas chromatography, working gas chromatography, application of gas chromatography, programmed temperature chromatography, flow programming chromatography, gas-solid chromatography, Columns for Gas Chromatography, choice of columns, polarity indices, Gas chromatography and Chirality.

**Ion chromatography** - Principle, structure and characteristics of resins, eluent, suppressor columns and detectors used in ion chromatography, analytical applications, environmental speciation by ion chromatography and applications. Hyphenated techniques in Chromatography.

**Unit-III :** **12L**

**Gel Filtration:-**

Introduction, types of gels, techniques used in equilibrium studies, estimating size parameters, molecular wt. determinations separating plant aspects.

**Electrophoresis**-Theory and classification, factors affecting mobility, macromolecular size and charge interactions with supporting electrolyte, pH and concentration discontinuities, Factors affecting electrophoresis phenomena-electrolysis, electrosomosis, temperature and supporting media. Instrumentation, methodology, Preparation of gel staining and destaining, preparative zone electrophoresis, continuous electrophoresis and Applications.

**Capillary Electrophoresis**-Principle, theory, instrumentation, sample preparation and applications, Capillary electrochromatography and Miscellar electrokinetic capillary chromatography

**Unit-IV :** **12L**

**Membrane-Based Methods:-Dialysis**-working of techniques, membranes, general consideration of diffusion, Donnan Membrane equilibrium and Applications.

**Electrodialysis**- working of techniques, membranes, Electrodialysis cells and Applications.

**Ultrafiltration**- working of techniques, membranes, non-gelatinous membranes and Applications. Dialysis compared with other membrane-separation methods.

**Other Separation Methods:-Ultracentrifugation**-Principle, sedimentation constant, sedimentation equilibrium, sedimentation velocity, methodology and applications.

**Zone refining**- Principle, zone leveling and applications

**Unit-V :** **12L**

**Kinetic Methods of analysis-**

Theoretical basis of kinetic methods of analysis, Rates of chemical reactions, rate laws, first order, second order kinetics, pseudo first order and second order reactions, factors affecting rate of reaction, methods of determining amount of the substance (tangent method) fix time and concentration method, addition method, oxidation reactions of  $H_2O_2$  (thiosulphate, iodide, unimol), enzyme catalyzed reaction, inhibition and activation. Types of kinetic methods, differential and integral, applications.

**Books Suggested :**

1. Basic Concept in Analytical chemistry, by S.M. Khopkar.
2. Day & Underwood: Quantitative Analysis.
3. A. I. Vogel A Text book of Quantitative inorganic Chemistry, ELBS, London.
4. Analytical Chemistry, D.C. Das, PHI Learning Pvt. Ltd, New Delhi
5. Chromatography. By E Heftman, 5th edition, part-A and part-B, Elsewhere Science Publisher, 1992
6. S. Wilson & P. Jones: Chemical Analysis Vol I
7. Chromatography Today. By C F Poole and S K Poole, Elsewhere Science Publisher, 1991.
8. H.H. Willard, L.L. Merritt and J.A. Dean: Instrumental Methods of Analysis (Van Nostrand).
9. B. L. Krayner, H. H. Willard. L. Merritt, J. A. Dean & F. A. Settle: Instrumental Methods of Analysis (CBS Publishers, Delhi, 1986)
10. Analytical Chemistry. By G D Christian 4th edition, John Wiley and Sons, 1986. L. R. Snyder & C. H. Harvath: An Introduction to Separation Science (Wiley Interscience)
12. F. J. Wicher Robert: Standard Methods Chemical Analysis.
13. G. L. Davis Krupadanam, D. Vijaya Prasad, K. Varaprasad Rao, KLN Reddy, C. Sudhakar, Analytical chemistry.
14. R. D. Budhiraja Separation Chemistry, New Age.
15. R.L. Peesok and L.D. Shield: Modern Methods of Chemical Analysis.

- 16 Electrophoresis- Analytical Chemistry. Open Learning by M Melvin John Wiley and Sons.1987
- 17 Analytical Chemistry, S.P.J. Higson, , Oxford University Press
18. Chemical Separations and Measurement; Theory and Practice, D.G.Peters, J.M.Hayes and G.M.Hieftje, Saunders Golden Sunburst Series.

### Semester III

#### Paper XII

#### Analytical Chemistry (Special Paper-II)

#### Recent Advances in analytical chemistry

Total Lectures: 60Hrs, 4Hrsper week, 12Hrs/unit Total Marks-80

#### Unit-I : 12L

##### High Performance liquid Chromatography:-

Principles, Instrumentation, Pumping systems, sample injection system, Columns and columns packings, Stationary support in HPLC, applications, Validation of HPLC method . Preparative HPLC, Fast HPLC, Trouble shooting in HPLC, Flash chromatography, Capillary HPLC

**Super critical fluid chromatography**, Introduction, properties of super critical fluids, characteristics of super critical fluid, Instrumentation and applications of SFC, Comparison of HPLC with SFC..

**Super critical fluid extraction**-Introduction, advantages of SFE, instrumentation , supercritical fluid choice, offline and on-line extraction and application.

#### Unit-II : 12L

**Functional group analysis**- terminal methylene group, nitro and Grignard reagent by titrimetry. Analytical organic reagents, specificity, selectivity, sensitivity, stability, masking, demasking, types of organic reagents and principles of underlying the uses of 2-pyridylazo-nathtol (PAN), dithizone, 8- hydroxyquinoline, magneson I & II phenyl arsonic acid, rubeanic acid and ethylene-diamine tetraacetic acid EDTA.

#### Unit-III : Recent advances in Analytical chemistry:- 12L

Ultra purity, ultra trace analysis, laboratory designing, purifications of reagents, pre-concentration techniques, methods of trace analysis such as NAA, XRF, EDX, AAS, and ICP. High purity materials for electronics industry, contamination, control during analytical operations. Importance of speciation analysis

#### Unit-IV : 12L

**Partical size determination**- Introduction, low angle light scattering, instrumentation, theoretical models and application. Dynamic light scattering-principles, instrumentation and applications. Photosedimentation-settling velocity and partical size, instrumentation and applications.

**Surface charactenzation by spectroscopy & microscopy**:- Introduction to the study of surfaces, types of surface measurements, spectroscopic surface methods, general techniques in surface spectroscopy, sampling of surfaces, surface contamination. Scanning electron microscopy (SEM) and scanning probe microscopy.

#### Unit-V : 12L

##### Sensors:-

Glass membrane electrodes-solid state sensors-liquid membrane electrodes-gas sensing and enzyme electrodes-interferences-ion activity evaluation method-measurement of pH-glass electrode for pH measurements-electrometric measurement of pH. Bio-sensors-principles, types and applications

#### Book Suggested:

1. Analytical chemistry- Problems and Solution- S. M. Khopkar, New Age International Publication.
2. Day & Underwood: Quantitative Analysis.
3. Findley: Practical Physical Chemistry:
4. Vogel A Text book of Quantitative inorganic Chemistry, ELBS, London.
5. Strouts Galfillal: Analytical Y. Lyalikov: Physocochemical Analysis
6. S. M. Khopkar: Basic concep in Analytical Chemistry
7. Meites and Thomas: Advance Analytical Chemistry. (Mc Graw Hill)
8. H.H. Willard ,L.L. Merritt and J.A. Dean: Instrumental Methods of Analysis (Van Nostrand).
9. B. L. Krayar, H. H. Willard. L. Merrit, J. A. Dean & F. A. Settle: Instrumental Methods of Analysis (CBS Publishers, Delhi, 1986)
10. R. D. Brown Instrumental Methods of Chemical Analysis ,McGraw Hill
11. L. R. Shyder & C. H. Harvath: An Introduction to Separation Science (Wiley Interscience).

12. Elemental Analysis of Airborne Particles, Ed. S. Landberger and M. Creatchman, Gordon and Breach Science Publication.
13. Atmospheric pollution, W. Buch, McGraw Hill, New York.
14. Fundamentals of Air Pollution, S. J. Willason, Addison & Wesley Publishers.
15. Analytical Aspect of Environmental chemistry, D. F. S. Natush and P. K. Hopke. John Wiley & sons. New York.
16. Analytical chemistry- Problems and Solution- S. M. Khopkar, New Age.
17. Environmental Chemistry, J.W. Vanloon, Oxford University Press.

### Semester III

#### Practical V

#### Inorganic Chemistry Practical

Practical Workload 9 Hrs./week

100 Marks

#### Quantitative Inorganic Analysis:

- 1) Detection and determination of Ascorbic acid from biological sample.
- 2) Determination of Phosphates from plant samples by spectrophotometry.
- 3) Determination of iron from pharmaceutical samples and coordination compounds.
- 4) Determination of Calcium from given drug sample by complexometry.
- 5) Determination of Iron, Calcium and Phosphorus from milk powder.
- 6) Simultaneous Spectrophotometric determination of-
  - i) Chromium and Manganese
  - ii) Titanium and Vanadium.
  - iii) Cobalt and Chromium
- 7) Analysis of stainless steel (Cr/Ni)
- 8) To determine the stability constant and stoichiometry of Ferric-thiocyanate complex by spectrophotometrically.
- 9) To study the stoichiometry and stability of Fe<sup>3+</sup> salicylate complex by job's and mole ratio method spectrophotometrically.
- 10) Estimate the amount of copper (II) with EDTA photometric titration
- 11) Determination of capacity of anion and cation exchange resin by column method.
- 12) To estimate the amount of magnesium and zinc in the given sample solution by ion exchange chromatography method.
- 13) Separation and estimation of Fe<sup>2+</sup>, Co<sup>2+</sup> and Ni<sup>2+</sup> by anion exchanger.
- 14) Separation and estimation of Halide by anion exchanger.

- 15) Separation and estimation of-
  - i) Cobalt and nickel
  - ii) Calcium and Zinc and
  - iii) Zinc and Magnesium by anion exchange.
- 16) Separation and estimation of Fe<sup>3+</sup> and Mg<sup>2+</sup> by solvent extraction
- 17) Solvent extraction by binary mixtures i. e. Al/Mg, Mg/UO<sub>2</sub>, Cu/Ni, Cu/Co etc. and quantitative determination by spectrophotometry.
- 18) Nickel / Molybdenum / tungston/vanadium / Uranium etc by extractive spectrometric method.
- 19) Separation, identification and quantitative determination of metal ions by paper chromatography.
- 20) Separation and identification of sugars/ honey/halides by paper chromatography and determination of R<sub>f</sub> values
- 21) Thin layer chromatographic separation, identification and determination of R<sub>f</sub> values of
  - a. Metal ions (Mn, Co, Ni, Cu, Zn, Cd, Pb, alkali metals etc)
  - b. Amino acids/ Organic compounds
  - c. Sulpha drugs in tablets and ointments.
- 22) Estimation of zinc/metals by fluorimetrically.
- 23) Nephelometric determinations of sulphate, phosphate, silver.
- 24) Potentiometric determination of the percentage of sodium carbonate in commercial washing soda.
- 25) Water analysis:
  1. Determination of hardness, alkalinity, salinity, Halides, Fluoride, Nitrite, Nitrate, phosphate and Sulphate.
  2. Determination of DO, COD and BOD.
  3. Determination of toxic metals viz As, Cd, Pb, Hg, and Ni in water and wastewater by suitable method.

The Practical examination will be based on the Inorganic Chemistry.

Time: 6-8 hours (one day examination)

Marks: 100

|   |            |
|---|------------|
| I) Exercise -1 (Based on Instrumental)      | - 40 Marks |
| II) Exercise-2 (Based on Separation Method) | - 40 Marks |
| III) Record                                 | - 10 Marks |
| IV) Viva- Voce                              | - 10 Marks |

---

|       |             |
|-------|-------------|
| Total | - 100 Marks |
|-------|-------------|

---

#### List of Books-

1. Day and Underwood: Quantitative Analysis
2. Vogel A.I: A textbook of quantitative Inorganic analysis, Longman.
3. Flaschka: EDTA Titration

4. Meites and Thomas: Advanced Analytical Chemistry.
5. Ewing, G.W.: Instrumental Methods of Chemical Analysis, McGraw-Hill
6. Drago, R.S.: Physical Methods in Inorganic Chemistry
7. Christian G.D.: Analytical Chemistry
8. Khopkar S.M.: Basic Concept of Analytical Chemistry.
9. Kolltath and Ligane: Polarography
10. Braun: Instrumental methods of chemical Analysis
11. Willard, Merritt and Dean: Instrumental methods of Chemical Analysis, Van Nostrand
12. Strouts, Crifillan and Wison: Analytical Chemistry.
13. Skoog S.A. and West D.W.: Fundamental of Analytical Chemistry
14. Dilts R. V.: Analytical Chemistry
15. Jahagirdar D.V.- Experiments in Chemistry
16. Chondhekar T.K.- Systematic Experiments in Physical Chemistry, Rajbog S.W., Anjali Pubn.
17. Wlehev G.J.- Standard methods of Chemical analysis, 6<sup>th</sup> Ed.
18. Ramesh R & Anbu M, Chemical Methods for Environmental Analysis: Water & Sediment, Macmillan India.

**SEMESTER III**  
**ORGANIC**  
**PRACTICAL VI**

**9 Hours per week                      Total Hours: 90 hrs.                      Marks: 100**

**Unit-I : QUALITATIVE ANALYSIS.**

Separation and identification of the components of a mixture of two organic compounds (two solids, one solid and one liquid, and all two liquids) using chemical methods or physical techniques. Purification of the compounds by crystallization, chromatographic techniques (Minimum of 12 mixtures to be done)

**Unit-II : EXTRACTION**

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk.
3. Isolation of lactose from milk.
4. Isolation of nicotine from tobacco.
5. Isolation of piperine from black paper.
6. Isolation of lycopene from tomatoes.
7. Isolation of  $\beta$ -carotene from carrots.

**Unit-III : SPECTRAL INTERPRETATION**

Structure Elucidation of organic compounds on the basis of spectral data (UV, IR, <sup>13</sup>CNMR and Mass) (Minimum 12 compounds are to be analysed during regular Practical).

**Distribution of marks:**

|                                   |     |
|-----------------------------------|-----|
| Unit I .....                      | 40  |
| Unit II í í                       | 20  |
| Unit III                          | 20  |
| Record                            | 10  |
| Viva voce                         | 10  |
| ô ô ô ô ô ô ô ô ô ô ô ô ô ô ô ô ô |     |
| TOTAL                             | 100 |
| ô ô ô ô ô ô ô ô ô ô ô ô ô ô ô ô ô |     |

**Book Suggested :**

1. Modern Experimental Organic Chemistry-Royston M. Robert, John C. Gilbert, Lyu B. Rodewald, S. Wingrove.
2. Experimental Organic Chemistry- L. M. Harwood, C. I. Moodyø
3. Semi-microqualitative Organic analysis-N. D. Cheronis, J. B. Entrikin, E.M. Wodnett.
4. The Systematic identification of Organic compounds-R.L. Shrine, D.Y. Curtin.
5. Quantitative Chemical analysis ó A.I. Vogel.
6. Vogelø textbook of quantitative analysis (Revised)-J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham.
7. Experiment and technique in Organic chemistry-D. Pasto, C. Johnson and M. Miller.
8. Hand book of organic analysis ó qualitative and quantitative-H. Clark, Adward Arnold.

**Semester IV**  
**Paper-XIII**  
**SPECTROSCOPY-II**

60 Hours (Four hours/week)                      12 Hrs. / unit                      Max.Marks 50

- Unit-I :** A) Emission spectroscopy based upon plasma: Arc and spark atomization, spectra from higher energy sources, emission spectroscopy based upon plasma sources, atomic fluorescence method based upon plasma atomization. Emission spectroscopy based upon arc and spark sources. X-ray fluorescence and its principle, instrumentation and application in analytical chemistry. 6L

- B) Photoelectron spectroscopy: Basic principle, photoelectric effect, ionization process, Koopmans theorem PES and X-PES, PES spectra of simple molecule, ESCA, chemical information from ESCA. Auger electron spectroscopy-basic idea. surface characterization by spectroscopy and microscopy, (SEM). 6L

- Unit-II :** A) X-ray diffraction :Interaction of x-ray with matter, scattering and diffraction. Bragg method Debye-Sherrer method of X-ray structural analysis of crystals, index reflection, identification of unit cell from systematic absence in diffraction pattern structure of simple lattice and x-ray intensities structure factor , its relation to intensity of electron density procedure for x-ray structure analysis. 4L
- B) Electron diffraction : Scattering intensity Vs scattering angle, wierl equation, measurment techniques, elucidation of structure of simple gas phase molecules.Low energy electron diffraction and stucture of surface. 4L
- C) Neutron diffraction: Scattering of neutrons by solids and liquids magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell. 4L

- Unit-III** A) Raman spectroscopy: Classical and quantum theories of raman effects,Pure rotational and vibrational and vibrationalrotational raman spectra,selection rules,mutual exclusion Raman spectroscopy,coherent antistokes Raman spectroscopy (CARS).Applications for the study of active sites of metalloproteins. 6L
- B) Electron Spin Resonance Spectroscopy : Introductiuon ,basic principle.zero field splitting and kramers degeneracy, factors effecting the  $\delta g_0$  values,hyperfying splitting, determination of  $\delta g_0$  values.Instrumentation,working of instruments,sensitivity,concentration,choice of solvent. presentation of ESR spectra,application of ESR to study the free radicals,structure determination,reaction velocities,application to inorganic compounds including biological system and to inorganic free radicals such as  $\text{PH}_4^-$ ,  $\text{F}_2^-$ ,  $[\text{BH}_3]^-$ ,determination of oxidation state of metals,Eldor and Eldor techniques. 6L

- Unit-IV :** Mossbauer spectroscopy: Basic principle,spectral parameters and spectrum display.Doppler shift.recoilless emission of radition.isomer shift,quadrupole splitting,magnetic hyperfying splitting.application of the techniques to the studies of 1. Bonding and structure of  $\text{Fe}^{+2}$ ,and  $\text{Fe}^{+3}$  compounds including those of intermediate spin (2)  $\text{Sn}^{+2}$  and  $\text{Sn}^{+4}$  compounds - Nature of M-L bond, coordination number, Structure and (3) Detection of oxidation state and in equivalent MB atoms. Mossbauer spectroscopy of Biological Systems. 12L
- Unit-V :** Structural Problem : Problems based on IR, Mass, UV, PMR,  $^{13}\text{C}$  NMR data and structure determination of organic molecules / inorganic compounds. 12L

#### Books suggested

- 1) Spectroscopic identification of organic compound-RM Silverstein,GC Bassler and TC Morril,John Wally
- 2) Introduction to NMR spectroscopy-RJ Abraham,J Fisher and Ploftus Wiely
- 3) Application of spectroscopy to organic compound-JR Dyer,Printice Hall
- 4) Organic spectroscopy-William kemp,ELB with McMillan
- 5) Spectroscopy of organic molecule-PS Kalsi,Wiley,Esterna,New Delhi
- 6) Organic spectroscopy-RT Morrison,and RN Boyd
- 7) Practical NMR spectroscopy-ML Martin,JJ Delpenck, and DJ Martyin
- 8) Spectroscopic methods in organic chemistry-DH Willson,I Fleming
- 9) Fundamentals of molecular spectroscopy-CN Banwell
- 10) Spectroscopy in organic chemistry-CNR Rao and JR Ferraro
- 11) Photoelectron spectroscopy-Baber and Betteridge
- 12) Electron spin resonance spectroscopy-J Wertz and JR Bolten
- 13) NMR óBasic principle and application-H Guntur
- 14) Interpritation of NMR spectra-Roy H Bible
- 15) Interpritation of IR spectra-NB Coulthop
- 16) Electron spin resonance theory and applications-W gordy
- 17) Mass spectrometry organic chemical applications ,JH Banyon

**Semester IV**  
**Paper XIV**  
**General Analytical Chemistry**

Total Lectures: 60Hours, 4Hours per week, 12Hours/unit Total Marks: 50

- Unit-I** : 12L  
**Radiochemical Methods:** Elementary working, principles of Geiger Muller, Ionisation, proportional and I-ray counters. Radiotracer techniques, application of radiotracers in analytical chemistry. Neutron activation analysis (NAA): Principle, technique and applications in preparation of some commonly used radioactive isotopes. Isotopic Dilution Analysis (IDA), substoichiometric IDA, experimental technique and applications of IDA, advantages and limitations of IDA and comparison of IDA with NAA. Principle of Radiometric titrations, types, Experimental techniques and its applications. Carbon dating. Numericals.
- Unit-II** : **Online Analyzers** 12L  
**Automation in Chemical Analysis:** Introduction, Classification of automated methods, principles and techniques of auto-analyzers employed for microanalysis with emphasis on the basis sequences in operational modes in segmented and non-segmented flow and applications. Selection of online analyzers.  
Flow Injection Analysis: Introduction, principal, theoretical aspects of FIA, techniques, pretreatment of sample in packed reactors, components of FIA apparatus, Factors affecting FIA and applications for the determination F<sup>-</sup>, Cl<sup>-</sup>, PO<sub>4</sub><sup>-</sup>, SiO<sub>3</sub><sup>2-</sup>, NO<sub>2</sub><sup>-</sup>+NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, BO<sub>3</sub><sup>3-</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Al<sup>3+</sup>, Mn<sup>2+</sup>, Cr<sup>6+</sup>, Fe<sup>3+</sup> in water.
- Unit-III** : **Optical Methods Of Analysis:** 12L  
**A) Molecular Luminescence Spectroscopy:** Introduction, Molecular fluorescence, phosphorescence and Chemiluminescence, theory, factors affecting fluorescence and phosphorescence, instrumentation and analytical applications. Applications of fluorimetry. Fluorescence quenching. Photoacoustic spectroscopy: Theory, Instrumentation, PAS-gases and condensed systems, chemical and surface applications. Qualitative and quantitative analysis.  
**B) Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPAES):**  
Principles, atomization and excitation, ICP-source, Instrumentation and applications.

- Unit-IV: Analysis of Food, Body fluids and Drugs:** 12L  
**A) The chemical and nutritional composition of food:** analysis of trace elements such as Pb, As, Cd in food, Analysis of Tea, Milk, Spices. Chemical preservation of food, Analysis of sodium benzoate and sodium metabisulphite, Analysis of adulterants in food, Analysis of artificial sweeteners in food and colouring agents.  
**B) Clinical Chemistry and Drug Analysis:** Composition of blood, collection and preservation of samples, clinical analysis, serum electrolytes, blood glucose, blood urea nitrogen, uric acid, albumin, globulin, barbiturates, acid and alkaline phosphatases. Immunoassay :principles of radio immunoassy(RIA) and applications. The blood gas analysis trace elements in the body. Narcotics and dangerous drugs, classification of drugs, screening by gas and thin layer chromatography and spectrophotometric measurements
- Unit-V** : **Fuel analysis:** 12L  
Solid, Liquid and gaseous fuels. Characteristics of ideal fuels. Ultimate and proximate analysis of coal, heating values, grading of coal, liquid fuels-flash point, aniline point, knocking, antiknock compounds, octane number, cetane number and carbon residue. Gaseous fuels, producer gas and water gas, determination of calorific value. Analysis of fuel Gas. Numerical problems.

**List of Books-**

1. Day and Underwood: Quantitative Analysis
2. A. I. Vogel: A text book of quantitative Inorganic analysis.
3. Flaschka: EDTA Titration
4. Meites and Thomas: Advanced Analytical Chemistry.
5. G. W. Ewing: Instrumental Methods of Chemical Analysis.
6. R. S. Drago: Physical Methods in Inorganic Chemistry
7. G. D. Christian: Analytical Chemistry
8. S. M. Khopkar: Basic Concept of Analytical Chemistry.
9. Kolltath and Ligane: Polarography
10. R.D.Braun: Instrumental methods of chemical Analysis
11. Willard, Merritt and Dean: Instrumental methods of Analysis
12. Strouts, Crifillan and Wison: Analytical Chemistry.
13. J. W. T. Spinks and R. J. Woods: Introduction to Radiation Chemistry.
14. S. A. Skoog and D. W. West: Fundamental Of Analytical Chemistry
15. R. V. Dilts: Analytical Chemistry

Semester IV  
Paper-XV  
Special Paper-III

**Inorganic Chemistry (Photoinorganic & Organometallic Chemistry)**

**Total Lectures: 60Hrs, 4 Hrs per week, 12 Hrs/unit    Total Marks-50**

- Unit-I :** 12L
- A) Basics of Photochemistry:** Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times-measurements of the times. Flash photolysis, stopped flow techniques, Energy dissipation by radiative and no-radiative processes, absorption spectra, Frank-Condon principles; photochemical stages-primary & secondary processes.
- B) Properties of excited states:** Photochemical kinetics, Calculation of rates of radiative processes.
- Unit-II** 12L
- A) Excited States of Metal Complexes:** Electronically excited states of metal complexes, charge transfer spectra, charge transfer excitations, methods for obtaining charge transfer spectra.
- B) Ligand field Photochemistry:** photosubstitution, photo oxidation & photoreduction.  
Liability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.
- Unit-III** 12L
- A) Redox reactions by Excited Metal Complexes:** Energy transfer under conditions of weak interaction & strong interaction & exciplex formation, conditions of excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2-bipyridine & 1,10-Phenanthroline complexes.), illustration of reducing and oxidizing character of ruthenium (II); role of spin-orbit coupling, lie time of these processes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants in to high-energy products, chemical energy in to light.
- B) Metal Complex Sensitizers:** Metal Complex Sensitizers, electron relay, metal colloid systems, and semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation & carbon dioxide reduction.

- Unit-IV :** 12L
- Organotransition Metal Chemistry:**  
Alkyls and Aryls of Transition Metals:  
Types, routes of synthesis, stability & decomposition pathways of alkyls & aryls of transition metals.  
Organocopper in Organic synthesis.  
Compounds of Transition Metal & Carbon Multiple bonds:  
Alkylidenes, alkylidynes, low valent carbenes & carbynes & synthesis, nature of bond, structural characteristics, nucleophilic & electrophilic reactions on ligands, role in organic synthesis.
- Unit-V :** 12L
- Transition Metal Pi Complexes-**Carbon multiple bonds.  
Nature of bonding, structural characteristics & synthesis, properties of transition metal pi- Complexes with unsaturated organic molecules, alkenes alkynes, allyl, diene, dienyl, arene & trienyl complexes. Application of transition metal, organometallic intermediates in organic synthesis relating to nucleophilic & electrophilic attack on ligands, role in organic synthesis.
- Books:**
1. Elschenbroich Ch. and Salzer A.: Organometallics, VCH, Weinheim, NY
  2. Balzani Vand Cavassiti V.: Photochemistry of Coordination compounds, AP, London
  3. Purcell K.F. and Kotz J.C., An Introduction to Inorganic Chemistry, Holt Sounder, Japan.
  4. Rohtagi K.K. and Mukharjee, Fundamentals of Photochemistry, Wiley eastern
  5. Calverts J.G. and Pitts J.N., Photochemicals of Photochemistry, John Wiley
  6. Wells, Introduction of Photochemistry
  7. Paulson, Organometallic Chemistry, Arnold
  8. Rochow, Organometallic Chemistry, Reinhold
  9. Zeiss, Organometallic Chemistry, Reinhold
  10. Gilbert A. and Baggott, J., Essential of Molecular Photochemistry, Blackwell Sci. Pub.
  11. Turro N.J. and Benjamin W.A., Molecular Photochemistry
  12. Cox A. and Camp, T.P. Introductory Photochemistry, McGraw-Hill
  13. Kundall R.P. and Gilbert A., Photochemistry, Thomson Nelson Coxon J and Halton B., Organic Photochemistry, Cambridge University Press.



**Semester IV**  
**Paper-XVI**  
**Special paper-IV**  
**Inorganic Chemistry (Materials Chemistry)**

Total Lectures: 60Hrs, 4 Hrs per week, 12 Hrs/unit      Total Marks-50

**Unit-I : Glasses, Ceramics & Composites: 12L**

**Glass:** A general idea of Glassy state, types, their composition & properties, glass formers & modifiers, optical glass, coloured glasses, lead glass, neutron absorbing glass.

**Ceramics:** General introduction, types, manufacturing process, structure, mechanical properties.

**Unit-II 12L**

**A) Liquid Crystals:** Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematics & smectic mesophases; smectic-Nematic transition clearing temperature-homeotropic, planar & schlieren textures twisted nematics, chiral nematics, molecular arrangement in smectic A & smectic C phases, optical properties of liquid crystals. Dielectric susceptibility & dielectric constants.

Lytotropic phases & their description of ordering in liquid crystals.

**B) Bio-materials:** Biomineralisation, controlled formation of biological composites, bone & other mineralised tissues, materials of construction, applications (General aspect only).

**Unit-III : 12L**

**Nanoparticals & Nanostructural materials :** Introduction, methods of preparation, physical properties, and chemical properties. Molecular Precursor routes to inorganic solids:- Introduction, sol-gel chemistry of metal alkoxide, hybrid organic-inorganic compounds

**Nanoporous Materials:** Introduction, Zeolites & molecular sieves, determination of surface acidity, porous lamellar solids, composition-structure, preparation & applications.

**B) Solid State Reaction:** General principles, reaction rates, reaction mechanism, reaction of solids, factors influencing reactivity, photographic process.

**Unit-IV 12L**

**A) Fertilizers:** Classification of fertilizers, nitrogen fertilizers, phosphate fertilizers, N, P, K fertilizers,  $H_3PO_4$  production without using  $H_2SO_4$ .

**B) Coordination Polymers:**

Natural polymers and reactions yielding coordination polymers. Synthesis of coordination polymers. Use of polymeric ligands in synthesis of coordination polymers. Metal coordination polymers. Silicon polymers. Organosilicon polymers. Synthesis and their uses.

**Unit-V: 12L**

**Catalysis:** Basic principals, thermodynamic and kinetic aspects, industrial requirements, classification, theories of catalysis, homogeneous and heterogeneous catalysis. Introduction, types & characteristics of substrate-catalyst interactions, kinetics and energetic aspects of catalysis, selectivity, stereochemistry, orbital symmetry and reactivity. Catalytic reactions of coordination and Organometallic compounds including polymerization activation of small molecules, addition to multiple bonds, hydrogenation, Zeigler-Natta polymerization of olefins, hydroformylations, oxidations, carbonylations and epoxidation.

**Books Suggested:**

1. Barsoum, M.W., Fundamentals of Ceramics, McGraw Hill, New Delhi
2. Ashcroft, N.W. and Mermin, N.D., Solid State Physics, Saunders College
3. Callister W.D., Material Science and Engineering, An Introduction, Wiley
4. Keer, H.H., Principles of Solid State, Wiley Eastern
5. Anderson J.C., Lever K.D., Alexander J.M and Rawlings, R.D., ELBS
6. Gray G.W. Ed. Thermotropic Liquid Crystals, John Wiley
7. Kelkar and Hatz Handbook of Liquid Crystals, Chemie Verlag.
8. Kalbunde K.I., Nanoscale Materials in Chemistry, John Wiley, NY.
9. Shull R.D., McMichael R.D. and Swartzendruber L.J., Studies of Magnetic Properties of Fine particles and their relevance to Materials Science, Elsevier Pub. Amsterdam
10. Breck D.W., Zeolite Molecular Sieves: Structure Chemistry and Use, Wiley Chichester, Eng.
11. Morrish A. H., Haneda K., Zhou X. Z. In Nanophase Materials: synthesis, properties, applications, Kulwer, London.

## Organic Chemistry (Organic Synthesis: II)

Total Lectures: 60Hrs, 4 Hrs per week, 12 Hrs/unit Total Marks-50

**Unit-I :** A) **Chemo and Regio Selectivity.** 6L  
Selectivity in organic synthesis, chemo and regio selectivity, stereoselective and stereospecific reactions, Kinetic and Thermodynamic control in reaction.

B) **Application of organometallics in organic synthesis.**  
Use of Organometallic compounds of Mg, Li, Zn, B, Sn and organocopper compounds in organic synthesis. Organotransition metal reagents of C, R, Fe, Co, Rh, Ni and Pd.

**Unit-II :** **Designing the synthesis based on retrosynthetic analysis** 6L  
12L

A disconnection approach to the synthesis of organic compound. Different consideration in designing target molecule, concept of synthon, FGI, Chemoselectivity, regioselectivity, specificity, stereoselectivity, general strategy choosing a disconnection. Types of bond disconnection, some of the applications of these concepts in designing the synthesis of common important class of the compounds.

**Unit-III:** A) **Protection and Deprotection of functional groups** 12L

Protection and deprotection of functional groups like, hydroxyl, amino, carbonyl and carboxylic acids groups, techniques employed for these.

B) **Phase Transfer Catalysis and Crown ethers.** Their methods of preparation and application in Organic Synthesis, Mechanism of Phase transfer reaction.

**Unit-IV** A) **Selective Organic Name Reaction** 12L  
Stark-Enamine reaction, Michel addition, Favorski reaction, Mannich reaction, Sharpless asymmetric epoxidation, Ene reaction, Baeyer-Villiger reaction.

B) **Reagents in Organic Synthesis:** Use of following reagents in Synthesis and functional group transformations such as complex metal hydrides, Gilman reagents, Lithium dialkyl cuprate LDA, DCC, Trimethyl silyl Iodide, Tributyl Tin hydride, Woodward and Prevost Hydroxylation, DDQ, Peterson Synthesis, Wilkinson's Catalyst, Becker Yeast.

**Unit-V:** A) **Polynuclear Hydrocarbons:** 12L  
Introduction, Comparative study of the aromatic character of linear and nonlinear Ortho fused Polynuclear Hydrocarbon. General methods of preparation of fluorine, anthracene and phenanthrene.

B) **Heterocyclic Compounds:**  
Nomenclature and familiarity with the heterocyclic ring (3-7 members containing up to 3 heteroatoms). Detailed chemistry of Pyrazole, imidazole, oxazole, thiazole, thiazine, pyrimidines, pyrazines and zepines

**Books suggested.**

- 1) Principle of organic synthesis. ROC Norman & JM coxon
- 2) Modern synthetic reaction. H.O. House W.A. Benjamin
- 3) Organic synthesis, The disconnection approach-S. Warren
- 4) Designing organic synthesis-S. Warren
- 5) Some modern methods of organic synthesis-W. Carruthers,
- 6) Advance organic reaction. Mechanism & structure-Jerry March
- 7) Advance organic chemistry Part-B-F.A. Carey & RJ Sundberg, Plenum P.
- 8) Organic reaction and their mechanism-PS Kalsi
- 9) Protective group in organic synthesis-TW Greene, & PGM
- 10) The chemistry of organophosphorous-AJ Kirby, & SG Warren
- 11) Organosilicon compound-C. Eabon
- 12) Organic synthesis via Boranes-HC. Brown
- 13) Organoborane chemistry-TP Onak
- 14) Organic chemistry of boron-W. Gerrard
- 15) Fundamentals of photochemistry-KK Rohatgi & Mukharji
- 16) Photochemistry-Cundau & Gilbert
- 17) Aspects of organic photochemistry-WM Horspoot
- 18) Photochemistry-JD Calvert
- 19) Photochemistry-RP Wayne

**SEMESTER-IV****Paper XVI****ORGANIC CHEMISTRY (Natural Product-II)**

**Unit-I :** **Synthesis Polymers and Rubbers -** 12L

A) **Synthesis Polymers-** Introduction, types of polymerization, Mechanism of condensation Polymerization, Addition polymerization free radical cationic, anionic and copolymerization, chain transfer agents, stereoregulated polymers. Atactic, Isotactic and syndiotactic polymers.

- B) Study of synthetic Rubbers: Buna S SBR, cold rubber, Buna N, NBR, Butyl Rubber, polyisoprene, polyurethanes, vulcanization mechanism, foaming agents, plasticizers, stabilizers, silicones.

**Unit-II : General aspects of drug: 12L**

Historical, Definitions used in drug chemistry-pharmacy, pharmacology, pharmacodynamics, pharmacodynamic agents, metabolite and antimetabolites, gram positive and gram negative Bacteria, Virus, Actinomycetes, Mutation, Chemotherapy, Nomenclature of medicinal compounds.

Classification of drugs on basis of their

Therapeutic actions.

1. Chemotherapeutic agents

2. Pharmacodynamic agents

Mechanism of Chemotherapeutic action:

1. Biological defences

2. Chemical defences

a) Surface active agents

b) Metabolic Antagonism

Assay of Drugs:

1. Chemical assay

2. Biological assay

3. Immunological assay

**Unit-III DRUGS DESIGN: 12L**

Development of new drugs, procedures followed in drug design. Concept Of lead compound and modification concept of Prodrugs and Softdrugs structure activity relationship (SAR) Factors affecting bioactivity resonance, inductive effect, isosterism, Biosterism, Spatial consideration, theories of drug activity occupancy theory, Rate theory induced fit theory, Quantitative structure activity relationship.

History and development of QSAR, Concept of drug receptor interaction, Physico-Chemical parameter. Lipophilicity, Partition coefficient Electronic ionization constants, Steric Hindrance and surface activity parameters and redox potential. Free Wilson analysis, Hansch analysis LD-50, ED-50 (Mathematical derivatives of equations included)

**Unit-IV : MEDICINAL CHEMISTRY 12L**

- A) Antibiotics: Introduction, Penicillin V And G, Streptomycin, Chloramphenicol, Tetracyclins.

- B) Antimalarial : Chemotherapy of malaria, Aminoquinolines, pamaquine, chloroquine and sulphones.

- C) Antipyretic and Analgesic: Aspirin, salol, phenacetin, antipyrin.

**Unit-V: Vitamin and Natural Pigments 12L**

- A) Vitamins: Structure determination and chemistry of Thiamine (Vitamin B1) Ascorbic acid (Vitamin C) Vitamin E and A.

- B) Natural Pigments: Chemistry of Carotenes, anthocyanins, General study of porphyrins, structure and synthesis of Hemoglobin and chlorophyll.

**Books suggested :**

- 1) Chemistry of alkaloids-SW Pelletier.
- 2) Chemistry of steroids-LF Fisher & M Fisher.
- 3) The molecules of nature-JB Hendrickson.
- 4) Biogenesis of natural compound-benfield
- 5) Natural product chemistry & biological significance, J. Mann, RS Devison, JB Hobbs, DV Banthripde & JB Horborne.
- 6) Introduction to flavonoids-BA Bohm, Harwood
- 7) Chemistry of naturally occurring quinines-RH Thomson
- 8) The systematic identification of flavonoids-marby, markham, & thomos
- 9) Text book of organic medicinal chemistry-wilson, geswold
- 10) Medicinal chemistry Vol I & II-Burger
- 11) Synthetic organic chemistry-Gurudeep chatwal.
- 12) Organic chemistry of natural products Vol I & II-OP Agrawal
- 13) Organic chemistry of natural products-Gurudeep chatwal
- 14) A textbook of pharmaceutical chemistry-Jayshree Ghosh
- 15) Synthetic dyes series-venkatraman
- 16) Chemistry process industries-shreve & brink
- 17) Principles of modern heterocyclic chemistry-LA Paquette
- 18) Heterocyclic chemistry-J Joule & G Smith
- 19) Heterocyclic chemistry-morton
- 20) An introduction to chemistry of heterocyclic compound-JB Acheson
- 21) Introduction to medicinal chemistry-A Gringuade
- 22) Wilson & Gisvold text book of organic medicinal & pharmaceutical chemistry-Ed. Robert F. Dorge
- 23) An introduction to drug design-SS Pandey, & JR Demmock
- 24) Goodman and Gilman's pharmacological basis of therapeutics-
- 25) Strategies for organic drug synthesis & design-D Lednicer
- 26) Polymer science-v Govarikar

- 27) Principle of polymer chemistry-PJ flory  
 28) An outline of polymer chemistry-james q.allen  
 29) Organic polymer chemistry-KJ Saunders.

**Semester IV**  
**Paper- XV**  
**Special Paper-III**  
**Physical Chemistry**

60 Hours (4-Hours/week)      50 Marks      12 hours/Unit

**Unit-I : Liquid Crystals:**

- A) Mesomorphic behavior, thermotropic liquid crystals, nematic and smectic meso phases, smectic and nematic transitions, and clearing temperature, twisted nematics, chiral nematics molecular arrangement in smectic A and Smectic C phases, optical properties of liquid crystals  
 6L
- B) General properties of liquids: liquid as dense gases, liquid as disorder solid, different types of intermolecular forces in liquids, theory of liquids.  
 6L

**Unit-II Isotope Effect:**

Equilibrium isotope effects, equilibria in solution, primary kinetic isotope effect, semi classical treatment, quantum mechanical tunneling, reactions of Muonium, isotope effects of heavy atoms, secondary kinetic isotope effect.  
 12L

**Unit-III Reactions in solutions:**

- A) Reaction between ions: Influence of solvent, dielectric constant & ionic strength, pre-exponential factor, single sphere activated complex.  
 6L
- B) Ion dipole & dipole-dipole reaction, Diffusion controlled reaction, influence of hydrostatic pressure, substituent and correlation effect. Hammett equation, compensation effect, diffusion controlled reaction: full microscopic and partial microscopic diffusion controlled and ionic reactions.  
 6L

**Unit-IV Chemical kinetic methods:**

- A) Basic principle of chemical relaxation method, chemical relaxation in two and multi-step systems, thermodynamic aspect of chemical relaxation.  
 6L
- B) Experimental methods for relaxation kinetics and applications: Temperature jump method, electrical field jump method, ultrasonic relaxation method.  
 6L

**Unit-V Reaction Dynamics:**

- A) Molecular dynamical calculations for  $H + H_2$ ,  $Br + H_2$ , and more complex reactions. Chemi-luminescence: highly dilute flames, diffusion flames.  
 6L
- B) Molecular beams: Stripping and rebound mechanism, state to state kinetics, influence of reactant vibrational energy and rotational energy, spectroscopy of transition species.  
 6L

**List of Books:**

- 1) Physical chemistry by P.W. Atkins & dePaula 7<sup>th</sup> Edition
- 2) Chemical Kinetics by K.J. Laidler. III<sup>rd</sup> Edition. Pearson Education.
- 3) Liquid State by J.A. Pryde.
- 4) Theotropic Liquid Crystals by G.W. Gray, Wiley
- 5) Hand Book of Liquid Crystals by Kelkar & Hatz, Chemie Verlag.
- 6) A Dynamic Liquid State, A. F.M. Barton, Longman.
- 7) Chemical Kinetics & Dynamics by J.I. Steinfeld, J.S. Francisco & W.L.Hase. Printice Hall. 1989.
- 8) Kinetic & Mechanism of Chemical Transformation by J. Rajaram & J. Kuriacose, McMillion.

**Semester IV**  
**Paper- XVI**  
**Special Paper-IV**  
**Physical Chemistry**

60 Hours (4-Hours/week)      50 Marks      12 hours/Unit

**Unit-I Nuclear Chemistry:**

- A) General characteristics of radioactive decay, decay kinetics parent daughter decay growth relationship.  $\alpha$ - decay,  $\beta$ - decay, nuclear de-excitation, Secular and transient equilibrium,  $\alpha$ - particle energy spectrum, Geiger-Nuttall's Law, Theory of  $\alpha$ , and  $\beta$  decay process,  
 6L
- B) Detection and measurement of activity: The electrometer, the ionization chamber, electro pulse counter, scintillation, semiconductor, thermo-luminescence and neutron detector.  
 6L

**Unit-II Nuclear reactions:**

Bath's notation, types of nuclear reactions, conservation in nuclear reaction, reaction cross section, compound nucleus theory, experimental evidence of Bohr's theory: Experiments of Ghoshal, of Alexander and Simonoff specific nuclear reactions, trans uraniens, photonuclear reactions, thermonuclear reaction, fusion reactors, origin and evolution of elements.  
 12L

**Unit-III Nuclear fission:**

- A) Process of nuclear fission, fission fragments and their mass and charge distribution. Fission energy, fission cross-section and threshold. Theory of nuclear fission, fission neutrons, other types of nuclear fissions. 6L.
- B) Nuclear reactors: Nature of nuclear reactor, Natural Uranium reactor, classification of reactors critical size of thermal reactors, the breeder reactors. Reprocessing of spent fuel, nuclear waste management. 6L.

**Unit-IV Radiation Chemistry:**

Interaction of radiation with matter, Radiation track spurs and d-rays, linear energy transfer, Bathes equation for linear energy transfer, Bremsstrahlung effect. Passage of neutron through matter, Interaction of g-radiation with matter: photoelectric effect and Compton effect, pair production phenomenon, units of measuring radiation absorption, radiolysis of water, radiolysis of some aqueous solutions. 12L.

- Unit-V A) Radiation dosimetry:** Unit of radiation energy, chemical dosimeter, Fricke dosimeter and ceric sulphate dosimeter, conversion of measured dose values, Distribution of water, free radicals in water, radiation induced color centers in crystals. 6L.
- B) Applications of radioactivity:** Probing by isotopes, the Szilard-Chalmers reaction, cow and milk system. Principle and applications of radioisotopes as tracers, radioisotopes as source of electricity. 6L.

**List of Books:**

- 1) Introduction to radiation chemistry by J.W.T. Spinks and R.J.Woods.
- 2) Essentials of Nuclear chemistry by S.J.Arnikaar.

**Semester IV****Paper XV****Special Paper-III****(Unit Processes)****Industrial Chemistry**

60hrs (4hrs/week). 12hrs/unit

50 Marks

- Unit-I A) Nitration:** Introduction, nitrating agents, equipment for nitration, manufacture of nitrobenzene, Ortho and para nitrochlorobenzene.

- B) Amination by reduction:** Introduction, methods of reduction metal & acid, sulphide reduction, metal & alkali reduction, manufacture of aniline, meta nitro aniline
- C) Halogenation:** introduction, reagents of halogenation, aromatic halogenation, manufacture of chlorobenzene, dichlorofluoromethane

- Unit-II A) Sulphonation:** introduction, sulphonating agents, factor affecting sulphonation, equipment, manufacture of benzene sulphonic acid, sulphonation of anthraquinone
- B) Oxidation:** introduction, oxidizing agents, vapour & liquid phase oxidation, manufacture of acetic acid, acetaldehyde, benzoic acid.
- C) Hydrogenation:** introduction, catalyst used for hydrogenation, hydrogenation of vegetable oil, manufacture of methanol,

- Unit-III A) Esterification:** Introduction, esterification by organic acids, esters by adding unsaturated systems, manufacture of ethyl acetate, cellulose acetate.
- B) Hydrolysis:** introduction, hydrolysis agents, acid hydrolysis alkali hydrolysis, enzymatic hydrolysis, factors affecting hydrolysis,.
- C) Alkylation:** Introduction, alkylating agents, factors affecting alkylation, manufacture of ethyl benzene, phenyl ethyl alcohol

**Unit-IV - Petroleum Refining and Petrochemical Technology :**

- A) Petroleum refining practice
- Petroleum Refining in India
  - Indian Standards for Motor gasoline, Kerosene and Diesel
  - Atmospheric and vacuum distillation of crude
  - Petroleum coking and visbreaking
  - Fluidised catalytic cracking, catalytic reforming, catalytic alkylation, catalytic isomerisation.
  - Hydrocracking & Hydrotreating
  - Lube processing.
- B) Petrochemical Industry :
- Petrochemical Industry in India
  - Petrochemical Feed stocks.
  - Naphtha cracking & separation and purification of olefins to get ethylene, propylene, butylenes etc.
  - Manufacture of BTX aromatics
  - Butadiene & Xylenes separation techniques.
  - Important monomers like, Styrene, DMT & Caprolactum.

**Unit-V - Polymers**

- 1) Nomenclature, classification of polymer : Natural and synthetic polymers, organic and inorganic polymers, thermoplastic and thermosetting polymers, plastic elastomers, fibres and liquid resin, block & graft copolymers.
- 2) Types of polymerization: Addition (chain) : Polymerization- free radical, ionic, coordination and their mechanism, condensation (step) polymerization polycondensation, polyaddition, ring opening, linear and cross-linked and their mechanism, copolymerisation.
- 3) Techniques of polymerization : Bulk, solution, suspension and emulsion polymerization.
- 4) Molecular weight and size : Number-average and weight-average molecular weights viscosity-average molecular weight, degree of polymerization, significance of polymer molecular weight, size of polymer molecule; molecular weight determination: by Osmometry (membrane & vapour phase), end group analysis, viscometry and light scattering methods.
- 5) Physical characteristics of polymers : Glass transition temperature and crystallinity of polymer, Determination of Glass transition temperature.
- 6) Manufacturing, properties and uses of following polymers:
  - i) Natural and synthetic rubber
  - ii) Synthetic fibers ó polyesters, polyamides, rayons
  - iii) Synthetic plastics : Polyoliefins, polyurathanes
  - iv) Silicones

**List of Books-**

1. Unit Process in Organic Synthesis, by P. H. Groves
2. Modern Petroleum Technology by G. D. Hobson and W. Pohl.
3. Petroleum refining and engineering by W. L. Nelson.
4. Petroleum refining technology and economics by J. H. Gary and G. E. Handwerk.
5. The Petroleum chemical industry by Goldstein and Waddams.
6. Petroleum processing handbook by W. E. Bland and R. L. Davidson.
7. The Text book on Petrochemical by Dr. B. K. Bhaskar Rao, Khanna Publishers New Delhi.
8. Modern Petroleum refining Processes by Dr. B. K. Bhaskar Rao, Oxford, IBH, 1984
9. Petroleum product handbook, V. B. Guthrie.
10. Textbook of polymer science by F. Bill Mayer, Wiley Inter Science.

11. Polymer Science by V. Govarikar, N. Viswanathan and J. Sreedhar, New Age International (P) Ltd. Publishers New Delhi
12. Physical chemistry of polymers by D. D. Deshpande, Tata McGraw Hill.
13. Principles of polymer chemistry By P. J. Flory, Cornell Univ. Press.
14. Introduction to polymer chemistry by R. B. Seymour McGraw Hill.
15. A Practical Course in polymer chemistry by S. J. Pnnea, Pergamon press.
16. Labortary preparation of macro chemistry by E. M. M. Effery McGraw Hill.

**Semester IV**  
**Paper XVI**  
**Special Paper-IV**  
**(Chemical Processes Industries)**  
**Industrial Chemistry**

60hrs (4hrs/week). 12hrs/unit

50 Marks

**Unit-I : Dyes****12L**

- i) Chemistry of dyes :- Introduction, classification of dyes on the basis of structure and the mode of application to the fibre. Colour and chemical constitution of dyes. General methods of preparation of important azodyes, Cyanindyes and anthraquinone vat dyes.
  - ii) Chemistry of intermediates :- Introduction to the history of dyes. Natural to synthetic dyes.
    - 1) Manufacturing, properties and uses of following polymers:
      - i) Natural and synthetic rubber
      - ii) Synthetic fibers ó polyesters, polyamides, rayons
      - iii) Synthetic plastics : Polyoliefins, polyurathanes
      - iv) Silicones
- Mediates: - chloronitrobenzene Nitroanilines, diaminobenzenes.
- Napthalene intermediates :- Naphthyl sulphuric acids, Naphthyl amine sulphuric acids.
- Mescallaneous
- i) Amino anthraquinones, methyl & methylamino anthraquinones, Disperse dye intermediates, disperse ó reactive intermediates.

- ii) Analysis & applications of dyes :- Different methods used in analysis, Nitrate value determination, Coupling value, titanium chloride reduction, metal estimations of Cu, Ni, Cr etc.

Dyeing methods :- Dyeing methods for direct, acid, reactive disperse, vat, cationic, sulphur, indigo and azoics.

**Unit-II : Sugar Industries 12L**

Manufacturing of sugar from sugarcane : Introduction, agriculture, harvesting, preparation of cane for mashing, juice extraction, diffusion, juice purification, evaporation, crystallisation (production of raw sugar), centrifugation, sugar refining, decolouring, purification, filtration, crystallisation grade analysis.

**Analysis of bagasse and molasses, byproducts of sugar industries.**

**Unit-III : Pulp and paper industries 12**

- A) Chemistry of paper making, raw materials-
- physical properties of wood, classification of woods, plants used in pulp & paper, grass.
  - Chemical composition of wood, non-woody fibers used in pulping
  - Lignin-lignification of wood, chemical aspects of lignin formation.
  - Structure & properties of lignin
- B) Pulping:
- Preparation of pulp, wood, chips
- Manufacture of mechanical pulp, woods used, types, grades & uses.
- Equipment for ground wood pulping process
- Semichemical pulping, wood preparation, digesters
- Steam cooking
- Utilisation of secondary fibres.
- Rag pulping
- C) Bleaching
- bleaching of wood pulp-bleaching practice
  - stock preparation-internal sizing of papers
  - Filling paper manufacture - Additives
  - types of paper machine - sheet formation
  - press section - drying of papers
  - cylinder mould type -calendar
  - Speciality papers-injection moulding

**Unit-IV : Pharmaceuticals 12L**

Product profile study of the following drugs and intermediates with particular stress on the manufacturing process engineering problems involved, quality control, equipment and economics ;

- i) Sulpha drugs :- Sulphaguanidine, sulphamethoxazole.
- ii) Antimicrobial :- chloramphenicol, streptomycin, Tetracyclines, ciprofloxacin.
- iii) Analgesic :- anti-inflammatory, Acetyl Salicylic acid, Ibuprofen, paracetamol.
- iv) Vitamin ó Vit. A, Vit. B<sub>6</sub>, Vit. C
- v) Barbiturates :- Pentobarbital
- vi) Beta-blockers :- propranolol, atenolol, Beta-Nifedine, (Antihypertension)
- vii) Cardiovascular agent :- Methyldopa, enalapril maleate, Benazepril.
- viii) Antihistamines ó Chlorpheniramine maleate,
- ix) Antidepressants ó Reserpine, sertraline
- x) Anticancer drugs & antiacids.

**Unit-V : Agrochemicals 12L**

Inorganic insecticides :- Arsenic insecticides, fluoro insecticides

Insecticides of plant origin: - Nicotine, nicotine, pyrethroids, rotenoids, analogin, allethrin.

Chlorinated hydrocarbon:- DDT, dieldrin, DDT, endosulfan.

Organophosphorus Insecticides :-

Dithiophosphoric acid derivatives :- Malathion, dimethoate, Dimecron.

Diphosphoric acid derivatives :- Parathion, methyl parathion, thiophos, chlorpyrifos, diazinon.

Pyrophosphoric acid derivatives.

Sulphate, phosphoramide.

Other organophosphorus Insecticides.

Isoproturon, trichlorfon.

Carbamate insecticides.

Carbaryl, imidacloprid, phosalone, pyrethrin.

Fungicides:-

Inorganic Fungicides:-

Sulphur, limesulphur, copper sulphate, Bordeaux paste, Bordeaux paint, Burgundy, copper oxychloride.

Organomercuric compounds:-

Ethyl mercuric chloride, cereasn Dithiocarbamates- Ziram, thiram, Zinc, captan.

Miscellaneous fungicides :- Polpet, Bavistin

#### List of Books-

1. Synthetic dyes by Venkatram (VOL I & II)
2. Fundamental processes of dye chemistry, by Fietz.
3. Dyes and Intermediates by Adrahaedt
4. Chemical Process Industries by R. N. Shreves and M. J. A. Brink.
5. Pulp and paper chemistry and chemical Technology by James P. Casey
6. The chemistry of cellulose by Emit Ptauseg, John wiley and sons, New York.
7. Indian Pharmacopoeia, 1985
8. British pharamacopoeia, 1990
9. Textbook of Organic Medicinal and Pharmaceutical Chemistry by Willson, Jisvold, Dejjia, Lippinett Toppan.
10. Essentials of Medicinal Chemistry by Korolkovas and Burkhatther-Wiley-Interscience.
11. Pharmaceutical Dosage forms
12. Pesticites-Color Publications, P. L. Bombay
13. Elements of Plant Protection by L. L. Pyenson, John Wiley and sons.
14. Chemistry of Pesticides by N. N. Melnikov Springer-Verlag, New York
15. Fungicites in Plant Disease control by Y. L. Nines, Oxford and IBH Publishing company New Dehli.
16. Methods Pesticides Analysis by Sree Ramuly, U. I. Oxford and IBH Publishers.
17. Charles E. Dryden, Outline of Chemical Technology Edited by M. Gopal Rao and Marshall Siting, East West Press 2<sup>nd</sup> Edition 1973.

#### Semester-IV

#### Paper XV

Analytical Chemistry

Analysis of commercial products

Total Lectures: 60Hrs, 4Hrsper week, 12Hrs/unit Total Marks-80

**Unit-I :** **12L**

#### Pharmaceutical analysis:-

Requirement of a quality control laboratory for pharmaceutical units, SOP of sophisticated instruments,

source of impurities in pharmaceutical raw materials such as chemicals, reagents and solvents, atmospheric and microbial contaminants, packing errors, chemical instability, container contamination, physical changes, temperature effects, manufacturing and storage effects. General manufacturing processes, stability studies, shelf life fixation for formulated products. Introduction to pharmaceutical formulations, Standardization, Evaluation analysis of common drugs, Antibiotics-Chloramphenicol, Ampicilline, Terramycine.

Vitamins- Vitamin B<sub>12</sub>, B<sub>6</sub>, Vitamin K

Sulpha drugs-Sulphaguandine, Sulphapyrazine, Sulphanilamide Analysis of common drugs (aspirin, paracetamol etc..)

**Unit-II :** **12L**

**a) Analysis of petroleum and petroleum products-** Introduction, constituents and fractionation, Quality control requirements of petrol and petroleum products, safety and hazardous aspects. Analysis of petroleum products-specific gravity, viscosity, doctor test, sulphuric acid absorption, aniline point, vapour pressure and colour determination, cloud point, pour point. Determination of water, neutralization value, ash content estimation of sulphur and lead in petrol.

**b) Analysis of Explosive** -General methods, heat of explosion, hygroscopicity, moisture by Karl Fischer titration, qualitative tests of explosives, qualitative analysis of explosive mixtures, Dynamites. Blasting caps and electric detonators, primers, liquid propellants and solid propellants

**Unit-III :** **12L**

Analysis of Paints, soap and detergents

**Analysis of Paints and Pigments-** Preliminary inspection of sample, Test on the total coating. Separation of pigments, binder and thinner of latex paints, determination of volatile and non volatile constituents, flash points, separation of pigments, estimation of binders and thinners. Modification of binder. Identification and analysis of thinner.

#### Analysis of soaps-

General idea of soaps and detergents, sampling, separation, identification, determination of soap composition-fatty acids, total anhydrous soap and combined



alkali, potassium, water, determination of inorganic fillers and soap builders, determination of other additives.

**Analysis of Detergents**- types, method of analysis, sampling, separation, identification of components, determination of surfactants, determination of surfactants-anionic, cationic, non-ionic. Determination of Abrasives, Ammonia, Carbonates, Cellulose, Glycerine, Silicates, Sulphates, Phosphates, moisture content, saponification value.  
Analytical techniques used for analysis of soaps and detergents

**Unit-IV :****12L****Forensic Analysis-**

General introduction of forensic analysis, sampling, sample storage, sample dissolution, classification of poisons, lethal dose, significance of LD-50 and LC-50, general discussion of poisons with special reference to mode of action of cyanide, organophosphate and snake venom.

Analytical toxicology: Isolation, Identification, Estimation of poisonous materials such as lead, mercury and arsenic in biological samples. Quantification of drugs, insecticides, alkaloids and other products of synthetic and natural origin, ethyl alcohol, methyl alcohol, Zinc phosphides, effects of Kerosene and cooking gas. General discussion, Diagnosis and Management of poison, food poisoning, narcotic, stimulants, paralytic, antihistamine.

**Unit-V :****12L**

Analysis of cosmetics, creams, lotions and hair dyes:-

- a) **Composition of creams and lotions:** Determination of water, propylene glycol, non-volatile matter and ash content, analysis of borates, carbonates, sulphates, phosphate, chloride, Titanium and Zinc oxide.
- b) **Analysis of face powder:** Estimation of boric acid, Mg, Ca, Zn, Fe, Al and Ba
- c) Analysis of deodorants and antiperspirants-composition, analysis of fats and fatty acids, boric acid, zinc, iron, aluminium, lead, copper, mercury, phosphorus and urea.
- d) Analysis of ingredients of hair dyes.
- e) Analysis of Vanishing cream
- f) Analysis of Lipsticks

**List of Books-**

1. Pharmacopoeia of India Volume I and II.
2. Aids to the Analysis of Food and Drug by Nicholls
3. Standard Methods of Chemical Analysis. 6th Ed. Vol I & II (D. Van. Nostard comp) by F.J. Welcher
4. Forensic pharmacy by B.S Kuchekar, A.M Khadatare (Nirali Prakashan)
5. Treatise on Analytical Chemistry Vol..I & II by L.M. Kolthoff.
6. Separation Chemistry in Chemistry and Biochemistry. By Roy Keller, M Decker Inc
7. G D. Christian: Analytical Chemistry
8. Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2<sup>nd</sup> Ed Mc.Graw hill) by S.Ranganna.
9. Encyclopedia of Industrial chemical Analysis Vol I to 20 (John Wiley) Riech
10. Cosmetics by W D Poucher (Three volumes)
11. Willard, Merritt and Dean: Instrumental methods of Analysis
12. Strouts, Crifillan and Wison: Analytical Chemistry.
13. Textbook of Forensic pharmacy- B. M. Mithal 9th Edn (1993) National Centre, Calcutta. V. Malik, Drug and Cosmetics Act.
14. Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta
15. Forensic Pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakashan

**Semester-IV****Paper XVI**

Analytical Chemistry (Special Paper-IV)

Applied analytical chemistry

Total Lectures: 60Hrs, 4Hrs per week, 12Hrs/unit Total Marks-80

**Unit-I :****12L**

Agricultural analysis-I

**Soil analysis**- Classification and composition, Soil formation, weathering, (especially SRMs), composition soil sampling, field description of soils, physical analysis, determination of major and minor constituents, exchange capacity, soil reaction, chemical analysis as a measure of soil fertility. Analysis of constituents such as Nitrogen, Phosphorus, Potassium and micronutrients.

**Stock feeds analysis** - feeding stuffs, qualitative analysis and quantitative analysis.

**Plant analysis**- Preparation of sample, moisture determination- methods of washing, methods of plant

analysis- starch, sugars, determination of mineral constituents (Fe, Mn, Mo, Si, Ca, Mg, P, S, C and N).

**Unit-II : Agricultural Analysis-II 12L**

**Analysis of Fertilizers-** Sampling, sample preparation. Analysis of nitrogen, phosphorus and potassium. Nitrogen: urea nitrogen, total Kjeldahl nitrogen method, Ammonianitrogen, phosphorus: total phosphorus. available and non-available, alkalimetric ammonium molybdophosphate method, potassium : potassium by sodium tetraphenylborate method.

**Pesticides and insecticides analysis-** Introduction, classification, Analysis of organochlorine, organophosphorus and carbonate pesticides, analysis of DDT, gammexane, endosulphan, zinab, ziram, malathion, thiram, thiometon, simazine and chloridane . Green technologies in agriculture industries and water resource managements

**Unit-III 12L**

**Analysis of minerals, ores and alloys**

- a) Minerals and ores-Hematite, pyrolusite, ypsum, dolomite chromate, bauxite, limestone, illmenite and uranium ores.
- b) Metal and alloys analysis- iron, different kinds of iron, steel, Cu-Ni alloy, solder, bronze, aluminium alloy, ferroalloys of silicon, molybdenum, chromium, titanium and vanadium.

**Unit-IV : 12L**

**Industrial pollution-** Sugar industry, paper and pulp industry, nuclear power plant, polymer drugs, radionuclide analysis, disposal of wastes and their management. Principles of decomposition Biodegradability, classification of hazardous substances and water, chemical classes of hazardous wastes, hazardous substances to health better industrial process. Industrial Operation and Green Methodology . Introduction and evolution of green chemistry, green reagents, solvents and catalysts

**Hazardous substance analysis-** nature, source, treatment and disposal of hazardous waste, classification of hazardous substances and wastes, origin, toxic substances, chemical, classification hazardous wastes, physical and chemical methods of wastes treatment and preparation of waste and ultimate disposal of hazardous waste.

Case studies-Bhopal gas, Chernobyl, Three Mile Island, Minamata disasters.

**Unit-V : Analysis of mineral materials: 12L**

a) **Cement-** Loss on ignition, insoluble residue, total silica, sesquioxides, lime, magnesia, ferric oxide, sulphuric anhydride, air and dust pollution from cement plants, atmospheric dispersion of pollutants in cement industry.

b) **Glass and Glass-Ceramics-** Introduction, composition, methods of analysis- sampling and sample preparation, composition analysis- preliminary testing, decomposition. Chemical method for the individual constituents-Si, B, Pb, Zn, Al, Cl, Mg, Ti.

**List of Books-**

1. Agricultural Analysis. By Kanwar
2. A. I. Vogel: A text book of quantitative Inorganic analysis.
3. Soil Analysis. By Jackson.
4. Encyclopedia of Industrial Methods of Chemical Analysis. By F D Snell ( All series).
5. G. W. Ewing: Instrumental Methods of Chemical Analysis.
6. Standard Methods of Chemical Analysis. By F J Welchar
7. G D. Christian: Analytical Chemistry
8. S. M. Khopkar: Basic Concept of Analytical Chemistry.
9. Handbook of Air Pollution. By Stern, APHA , 1980.
10. Fundamentals of Analytical Chemistry 6th edition by D. A. Skoog, D. M. West and F. S. Holler
11. Industrial Chemistry by B. K. Sharma.
12. Strouts, Crifillan and Wilson: Analytical Chemistry.
13. Principle and practice of Analytical chemistry by F. U. Field and D. Keuley 3rd edition, Blackie and sons Ltd..
14. S. A. Skoog and D. W. West: Fundamental Of Analytical Chemistry.
15. Pollution Control in Process Industries by S. P. Mahajan.

**Semester IV**

**Practical-VII**

**Inorganic Chemistry Special**

Practical Workload 9 Hrs./week Time: 9-12 hours Marks: 100

- Unit-I**
- 1) Extraction and absorption spectral study of chlorophylls from green leaves.
  - 2) Determination of Phosphates from cold drink samples by spectrophotometry.

- 3) Analysis of talcum and nyclin powders (Mg-complexometry,  $ZnO/H_3BO_3$ )
- 4) Determination of iron in soap bar.
- 5) Analysis of N, P, K from fertilizer
- 6) Analysis of cement/paint/soil.

**Unit-II :** Study of complex formation:

- 1) To determine the formula and formation of a complex by spectrophotometry (Job's/ mole/Slope ratio methods)
- 2) To determine stepwise proton-ligand and metal-ligand stability constant of complex by Irving-Rossotti method.
- 3) To determine the instability constant of complex by potentiometry ( $AgNH_3$ , Ag-thiosulphate)
- 4) To determine the composition and formation constant of a Fe-SSA complex by conductometry.
- 5) Determination of composition and stability constant of complex by polarography.

**Unit-III:** Inorganic reaction mechanism:

Kinetics and mechanism of following reactions:

- 1) Substitution reactions in octahedral complexes (Acid/Base hydrolysis)
- 2) Redox reactions in octahedral complexes.
- 3) Isomerization reaction of octahedral complexes.
- 4) Enzyme kinetics in presence of metal ions.
- 5) To determine the corrosion rate of metal strip.
- 6) To study the 1,10 phenanthroline as corrosion inhibitor for mild steel in sulphuric acid.
- 7) To study the adsorption and desorption of gases on heterogeneous catalyst.

**Unit-IV: Solid State:**

- 1) Preparation of oxides and mixed oxides ( $Mn_2O_3$ , NiO,  $Cu_2O$ ,  $Fe_3O_4$ ,  $ZnFe_2O_4$ ,  $ZnMn_2O_4$ ,  $CuMn_2O_4$  and  $NiFe_2O_4$ )
- 2) Preparation of Silica and Alumina by sol-Gel technique.
- 3) To study the electrical conductivity of ferrites, Magnetites, doped oxides and pure samples and determine band gap.

**Unit-V :** Two/Three steps synthesis and characterization:

Synthesis of metal complexes/Polymers/Lanthanide complexes and their structural characterizations by possible physical methods such as: elemental analysis (N, S, M % etc.), m.p. Solubility, MW, molar conductance, magnetic moment, thermogravimetric analysis, IR and electronic spectral data, determination of crystal field parameters (minimum five)

**Book Suggested:**

1. Synthesis and Characterization of Inorganic Compounds, W. L. Jolly, Prentice Hall.
2. Inorganic Experiments, J. Derck Woollins, VCH.
3. Practical Inorganic Chemistry, G. Mairand, B. W. Rockett, Van Nostrand.
4. A Text Book of Quantitative Inorganic Analysis, A. I. Vogel, Longman.
5. EDTA Titrations. F. Laschka
6. Instrumental Methods of Analysis, Willard, Merit and Dean (CBS, Delhi).
7. Inorganic Synthesis, Jolly
8. Instrumental Methods of Chemical Analysis, Yelri Lalikov
9. Fundamental of Analytical Chemistry, Skoog D.A. & West D.M Holt Rinehart & Winston Inc.
10. Experimental Inorganic Chemistry, W.G.Palmer, Cambridge.
11. Solid state Chemistry, N.B.Haney
12. Introduction to Thermal Analysis, Techniques & Applications, M.E.Brown, Springer
13. Preparation and Properties of solid state Materials, Wilcox, Vol. I&II, Dekker
14. The Structure and Properties of Materials Vol.IV, John Wulff, Wiley Eastern.

The Practical examination will be based on the Inorganic Chemistry.

|  |            |
|--|------------|
| Time: 6-8 hours (Two days examination) | Marks: 100 |
| I) Exercise -1 (Synthesis & Analysis)  | - 40 Marks |
| II) Exercise-2 (Kinetics/complex)      | - 40 Marks |
| III) Record                            | - 10 Marks |
| IV) Viva- Voce                         | - 10 Marks |
| Total                                  | -100 Marks |

**SEMESTER IV****Practical VII****Organic Chemistry Special**

**Practical Workload 9 Hrs./week Time: 9-12 hours Marks: 100**

**Unit-I : QUALITATIVE ANALYSIS.**

Separation of the components of a mixture of three organic compounds (three solids, two solids and one liquid, two liquids and one solid, all three liquids and identification of any two components using chemical methods or physical techniques. Purification of the compounds by crystallization, chromatographic techniques (Minimum of 12 mixtures to be done)

**UNIT-II: ORGANIC ESTIMATION**

Organic Estimation.

1. Estimation of nitrogen.
2. Estimation of halogen.
3. Estimation of sulphur.

Spectrophotometric/calorimetric Estimation.

4. Estimation of streptomycin sulphate.
5. Estimation of B-12.
6. Estimation of amino acids.
7. Estimation of proteins.
8. Estimation of carbohydrates.
9. Estimation of Ascorbic acid.
10. Estimation of Aspirin.
11. Solvent extraction of oil from oil seeds and determination of saponification value, iodine value of the same oil.

**Organic practical :**

Two Days Examination - 9-12 Hrs.

100 Marks

**Distribution of marks:**

|               |            |
|---------------|------------|
| Unit I í í    | 40         |
| Unit II í í í | 40         |
| Record        | 10         |
| Viva-voce     | 10         |
| <b>TOTAL</b>  | <b>100</b> |

**BOOKS SUGGESTED :-**

1. Textbook of practical organic chemistry qualitative and quantitative analysis (Vol I & II)- A.I. Vogel.
2. Elementary practical organic chemistry small scale preparation (Langman)- A.I. Vogel.
3. A handbook of organic analysis.-H.T.Clark.
4. Systematic qualitative organic analysis óH. Middleton.
5. Advanced practical organic chemistry-N. K. Vishnoi.

6. Small scale organic preparation-P.J. Hill
7. Practical organic chemistry-H. Dupont Durst & George W.Gokal.
8. Experimental organic chemistry Part I & II, P. R. Singh, D. S. Gupta & K.S. Bajpai.
9. Vogel's textbook of practical organic chemistry-A.R. Tatchell

**Semester IV****Practical-VII****Physical Chemistry Special**

Practical Workload 9 Hrs./week Time: 9-12 hours Marks: 100

**Use of Computer Programmes 5 terms of practicals.**

Treatment of experimental data, X-Y plots, programs with data preferably from physical chemistry practical. Students will operate two packages I) MS-Word and II) MS-Excel.

**Part-A**

- 1) To find out Energy of activation & Temperature coefficient of hydrolysis of methyl / ethyl acetate
- 2) To find out Energy of activation of the reaction between potassium persulphate & potassium iodide.
- 3) Determination of partial molar volume of solute and solvent in binary mixture.
- 4) To study the variation of solubility of calcium sulphate with ionic strength and hence determine thermodynamic solubility product.
- 5) To study the adsorption of acetic acid on charcoal and prove the validity of Freundlich and Langmuir adsorption isotherm.
- 6) To determine the critical micelle concentration of soap.
- 7) To determine the molecular weight of high polymer by viscosity measurement.
- 8) To find out partition coefficient of Iodine/Benzoic/Salicylic acid between benzene and water.

**Part-B**

- 1) Determination of half wave potential of metal ions by polarography.
- 2) Simultaneous determination of suitable of metal ion by polarography
- 3) Analysis of aspirin conductometrically and potentiometrically
- 4) Determination of sodium , potassium, lithium and calcium by Flame photometric individually and mixture.
- 5) Electronics measurement of resistance with multimeter and use of Wistone Bridge for accurate measurement of resistance.
- 6) Determine the dipole moment of given liquid.

- 7) Plot the current voltage curve for copper sulphate and sulphuric acid using bridge platinum electrode.
- 8) Determine the transport number of ions by moving boundary method.
- 9) Determine the composition of binary mixture spectrophotometrically

### Physical Chemistry Practical :

#### Distribution of marks:

|                                  |            |
|----------------------------------|------------|
| Two Days Examination - 9-12 Hrs. | 100 Marks  |
| Unit A í í                       | 40         |
| Unit B í í í                     | 40         |
| Record                           | 10         |
| Viva-voce                        | 10         |
| <b>TOTAL</b>                     | <b>100</b> |

### Semester IV Practical-VII Industrial Chemistry Special

Practical Workload 9 Hrs./week      Time: 9-12 hours      Marks: 100

#### Multi step organic Synthesis:

- 1) Nitrobenzene - m-dinitrobenzene ó m-nitroaniline- m-nitrophenol. Anthranilic acid ó phenylglycine orthocarboxylic acid ó indigo
- 2) Cyclohexanone ó cyclohexanone oxime ó caprolactum.
- 3) Preparation of P- bromoaniline from aniline.
- 4) Preparation of Synthetic Zeolites.
- 5) Determination of  $\text{N}$  and  $\text{P}$  nitrogen and phosphorus containing fertilizer respectively by suitable methods.
- 6) Determination of Iron and Calcium from Cement by suitable methods.
- 7) Determination of Lead (Pb) from Opal Glass by suitable methods.
- 8) Experiments based on distillation under reduced pressure, fractional and steam distillation.
- 9) Measurement of flash point, ignition point, kinematic viscosity by U-tube method.
- 10) Estimation of Copper from ó fungicides.
- 11) Determination of pesticide contents in the soil.
- 12) Preparation of Methyl orange, Methyl red, orange II, Fluorescein, Quinoline, Anthraquinone.
- 13) Quantitative estimations of important commercially available drugs.

- 14) Qualitative analysis of commercial available drugs including chromatographic technique.
- 15) Preparation of simple drugs involving two or three steps.
- 16) Preparation of melamine ó HCHO resin.
- 17) Determination of number average molecular weight (Mn) by end group analysis by conductometric method.
- 18) Determination of average molecular weight of polymer by viscometric method.
- 19) Determination of reducing sugar in cane juice.
- 20) Determination of moisture content and ash content of wood sample.
- 21) Experiments based on simple & fractional crystallization.
- 22) Analysis of nonfibrous materials used in pulp industries such as caustic soda as  $\text{Na}_2\text{O}$ , Soda ash as  $\text{Na}_2\text{O}$ , lime as  $\text{CaO}$ .
- 23) Extraction of essential oils from medicinal plants (Tikhadi).
- 24) Separation of Chromium (VI) & Chromium (III) by TLC in wastewater sample from electroplating industry.
- 25) Preparation of selected pesticide formulations in the form of dusts, emulsions, sprays.
- 26) Determination of calorific value of fuels.

#### Distribution of marks:

The Practical examination will be based on the syllabus for Industrial Chemistry (Elective Paper).

|   |                    |
|---|--------------------|
| Time: 9-12 hours (Two days examination) | Marks: 100         |
| I) Exercise -1 (Synthesis)              | - 40 Marks         |
| II) Exercise-2 (Analysis)               | - 40 Marks         |
| III) Record                             | - 10 Marks         |
| IV) Viva- Voce                          | - 10 Marks         |
| <b>Total</b>                            | <b>- 100 Marks</b> |

#### List Of Books-

1. Practical Engineering by S. S. Dara.
2. Laboratory Preparation of Microchemistry by E. M. M. Effery, McGraw Hill.
3. Practical Course in Polymer Chemistry by S. J. Pnnea, Pargaman Press
4. Practical Pharmacognosy by T. B. Willis.
5. Practical Pharmacognosy by T. N. Vasudevan.
6. Indian Pharmacopea-1985, British Pharmacopea-1990.
7. Handbook of Drugs and Cosmetics by Mehrotra
8. Methods of Pesticide Analysis by Sree Ramuly U. I. Oxford and IBH Publishing Co.

9. Methods of testing for petroleum and petroleum products. IS 1448-1960 Part I to Part IV. Published by ISI New Delhi 1967
10. IP Stands for Petroleum and products Published Applied Service Publisher Ltd. London, 33<sup>rd</sup> Edition 1974.
11. American Stds. For testing Materials, New York 1967.
12. Textbook of Inorganic Chemistry by A. I. Vogel.
13. Instrumental Methods of Analysis by Willard, Merit and Dean
14. Industrial Chemicals, Faith et. al. Wiley Interscience New York
15. Textbook Of Practical Organic Chemistry by I. C. Voley.
16. Industrial Organic Chemistry by J. K. Stille
17. Unit Operations by Kale
18. Reagents for Organic Synthesis Fisher and Fisher.
19. Technique of Organic Chemistry Vol I, Part I- IV A. Weishberger.

#### Semester IV

#### Analytical Chemistry Practicals (Special)

Total Hours: 90 hrs. (9 Hours per week)

Marks: 100

- 1) Solvent extraction of Al/Mg or Mg/UO<sub>2</sub> using 8- hydroxy quinoline complex and determination by spectrophotometry.
- 2) Separation and estimation of copper and cobalt on cellulose Column.
- 3) Analysis of pyrolomite with respect to I) iron II) Manganese
- 4) Assay of sulphur drugs
- 5) Analysis of vit. C in juice and squashes
- 6) Determination of saponin value and iodine value of oil.
- 7) Determination of p- nitrophenol by colorimetry.
- 8) Determination of iron in syndets by colorimetric method.
- 9) Determination of Phenol by Conductometry.
- 10) Potentiometric determination of thiourea.
- 11) Estimation of calcium/sodium in the sample of dairy whitener by flame photometry.
- 12) Analysis of pigments with respect to Zn and Cr.
- 13) To determine the amount of each copper and bismuth or copper and iron (III) from the given mixture at 745 nm by spectrophotometric titration using solution of
- 14) EDTA identification of sulphur drug in tablets and ointments by TLC.
- 15) Fertilizer analysis for N, P, K
- 16) Analysis of iodized table salt for its iodine content.
- 17) Estimation of the purity of given azo dye colorometrically.
- 18) Chemical analysis of chilly and turmeric powder.
- 19) Simultaneous estimation of Cl and I by potentiometric method.

- 20) Colorimetric determination of simple ions (phosphate, sulphate, nitrate/nitrite, toxic heavy metals).
- 21) Analysis of soap and detergent.
- 22) Determination of alcohol from beverages spectrophotometrically using dichromate.
- 23) Determination of amount of Zinc from the given sample solution by Nephelometric/Turbidimetric titration using standard solution of Ba (NO<sub>3</sub>)<sub>2</sub> or
- 24) Pb (NO<sub>3</sub>) Analysis of Pharmaceutical mixtures
- 25) Simultaneous determination of Vitamic C and Vitamin E
- 26) Analysis of some common pesticides insecticides, plastics and detergents
- 27) To determine the amount of each para nitro-phenol and meta nitro-phenol from the given mixture by spectrophotometric titration using standard solution of NaOH (max-280 nm)
- 28) Estimation of sodium benzoate/sodium metabisulphite. boric acid and salicylic acid in food
- 29) Analysis of chrome steel alloy for chromium and nickel content
- 30) Agricultural analysis of soil sample, animal feeds, soil micronutrients, milk powder for Ca, Fe and P content.
- 31) Any other relevant expt. may be added

The Practical examination will be based on the syllabus of Analytical Chemistry (Special Papers).

**Time: 6-8 hours (one day examination)**

**Marks: 100**

I) Exercise -1 - 40 Marks

II) Exercise-2 - 40 Marks

III) Record - 10 Marks

IV) Viva- Voce - 10 Marks

ô ô

Total -100 Marks

ô ô

#### M.Sc. (Chemistry)

#### Semester-IV

#### Practical-VIII - Project Work

Time : 9 Hrs. Per Week

Marks : 100

The Students will develop utilities such as analytical spectra, simulation programmes that will supplement laboratory exercises in their subject of specialization. For this, variety of small research project designed by the teacher based on the interest of the student and capabilities should be worked out.

The project will be evaluated by external and internal examiners.

**Study Tour:** Educational / Industrial tour is compulsory for M.Sc. Chemistry.

(i) Semesters I / II : Visit to local industry.

(ii) Semester III / IV : Education tour to visit the industry / Research Laboratory.

**List of equipments/apparatus required for the M.Sc. Chemistry Semester-I to IV Practicals.**

|                                     |               |
|-------------------------------------|---------------|
| 1. Conductivity meter               | 03 nos./batch |
| 2. pH meter                         | 03 nos./batch |
| 3. Potentiometer                    | 03 nos./batch |
| 4. Polarimeter                      | 02 nos./batch |
| 5. Centrifuge machine               | 02 nos./batch |
| 6. Vacuum Pump                      | 01 no./batch  |
| 7. Hot air oven                     | 01 no./batch  |
| 8. Blower hot & cold                | 03 nos./batch |
| 9. Stop watch                       | 10 nos./batch |
| 10. Weight box con. 100 gm.         | 10 nos./batch |
| 11. Analytical double pan balance   | 10 nos./batch |
| 12. One pan electrical balance      | 10 nos./batch |
| 13. Tripple beam balance            | 02 nos./batch |
| 14. Melting point apparatus         | 02 nos./batch |
| 15. Spectro photometer              | 02 nos./batch |
| 16. Water still                     | 01 no./lab    |
| 17. Colorimeter                     | 02 nos./batch |
| 18. Thermostate                     | 01 no./batch  |
| 19. Electrodes platinum             | 03 nos./batch |
| Silver                              | 03 nos./batch |
| Glass                               | 03 nos./batch |
| Reference                           | 03 nos./batch |
| 20. Heating mantle                  | 02 nos./batch |
| 21. Glass double distillation unit  | 01 no./lab    |
| 22. Flamed Photometer               | 01 no./batch  |
| 23. LCR meter                       | 01 no./lab    |
| 24. Polarograph with recorder       | 01 no./lab    |
| 25. U. V. visible spectrophotometer | 1 no./lab     |
| 26. Standard cell                   | 02 nos./batch |
| 27. Muffle furnace                  | 01 no./lab    |
| 28. D.C. Voltmeter                  | 01 no./lab    |
| 29. Infrared lamp                   | 05 nos./lab   |

|                                     |               |
|-------------------------------------|---------------|
| 30. Refrigerator                    | 01 no./lab    |
| 31. Magnetic stirrer 2 ml, 5 ml.    | 02 nos./batch |
| 32. Dimmer state                    | 01 no./lab    |
| 33. Abbe's refractometer            | 01 no./batch  |
| 34. Sodium lamp for polarimeter     | 02 nos./batch |
| 35. T.L.C. Kit                      | 01 no./lab    |
| 36. Calorimeter                     | 01 no./lab    |
| 37. Bomb Calorimeter                | 02 nos./batch |
| 38. BOD analyser                    | 01 no./lab    |
| 39. Water analysis kit              | 01 no./lab    |
| 40. Computer-386/486                | 01 no./lab    |
| 41. U.V. Lamp                       | 02 no./lab    |
| 42. Ice making machine              | 01 no./lab    |
| 43. LCR bridge                      | 01 no./lab    |
| 44. HPLC                            | 01 no./lab    |
| 45. Deioniser                       | 01 no./lab    |
| 46. Ion exchange column             | 04 no./lab    |
| 47. Turbidity meter                 | 01 no./lab    |
| 48. Optical densitometer            | 01 no./lab    |
| 49. Orsat apparatus (gas analysis)  | 01 no./lab    |
| 50. Interferometer (ultrasound)     | 01 no./batch  |
| 51. Youyou balance                  | 01 no./lab    |
| 52. Hydraulic press                 | 01 no./lab    |
| 53. Shaking machine                 | 01 no./lab    |
| 54. G.M. Counter                    | 01 no./lab    |
| 55. Electrophoresis apparatus       | 01 no./lab    |
| 56. Karl-Fisher Titration apparatus | 01 no./lab    |
| 57. Power supply (regulator)        | 01 no./batch  |
| 58. Regulated furnace               | 01 no./lab    |
| 59. Thermocouple                    | 01 no./lab    |
| 60. Vacuum oven                     | 01 no./lab    |
| 61. Top pan balance                 | 01 no./lab    |
| etc.,                               |               |

**List of glasswares (main) for M.Sc. Chemistry Semester-I to IV Practicals**

|  |               |
|--|---------------|
| 1. Soxhlet set   | 02 nos./batch |
| 2. Kjeldahl's apparatus set<br>(for Nitrogen element estimation) | 02 nos./batch |
| 3. Distillation unit   | 04 nos./batch |
| 4. Separating funnel   | 10 no./batch  |

|   |               |
|---|---------------|
| 5. Steam distillation unit  | 02 nos./batch |
| 6. Vacuum desiccator  | 01 no./batch  |
| 7. Paper chromatography chamber   | 03 nos./batch |
| 8. Silica crucibles   | 20 nos./batch |
| 9. Sintered glass crucibles g4/g5   | 20 nos./batch |
| 10. Spot test plates  | 10 nos./batch |
| 11. Wash bottles  | 10 nos./batch |
| 12. Density bottles   | 10 nos./batch |
| 13. Viscometer  | 10 nos./batch |
| 14. Kippø apparatus   | 10 nos./batch |
| 15. Beakers, capacity :50 ml, 100 ml, 250 ml, 400 ml, 500 ml, 1000ml,                     |               |
| 16. Conical flask : 100 ml, 250 ml.   |               |
| 17. Burettes with stop cock, capacity : 2ml, 5 ml, 10ml, 25 ml.                           |               |
| 18. Lambda pipette  | 02 nos./batch |
| 19. Volumetric flasks, capacity : 10 ml, 25 ml, 50 ml, 100 ml, 250 ml, 500 ml,<br>1000ml. |               |
| 20. Measuring cylinder, capacity : 10 ml, 25 ml, 50 ml, 100 ml, 500 ml,<br>1000 ml        |               |
| 21. Pipette, capacity : 1 ml, 2 ml, 5 ml, 10 ml, 25 ml.                                   |               |
| 22. Stalagmeter   | 10 nos./batch |
| 23. Thermometer (b-24) 0 to 3600C (quick fit)   | 05 nos./batch |
| 24. Water suction pump (glass)  | 05 nos./batch |
| 25. Filtration flasks with buckner funnels 50 ml  | 10 nos./batch |
| 100ml   | 10 nos./batch |
| 250ml   | 10 nos./batch |
| 500ml   | 10 nos./batch |
| 26. Quick fit stand joints b-14, b-19, b24  |               |
| 27. China dishes  | 10 nos./batch |
| 28. Dessicators   | 10 nos./batch |
| 29. Thielø tube for melting point   | 05 nos./batch |
| 30. Quick fit water condensers b-19, b-24   | 10 nos./batch |
| 31. Quick fit flasks, Capacity 50 ml, 100 ml,<br>250 ml, 500 ml, 1000 ml.                 | 10 nos./batch |

\*\*\*\*\*