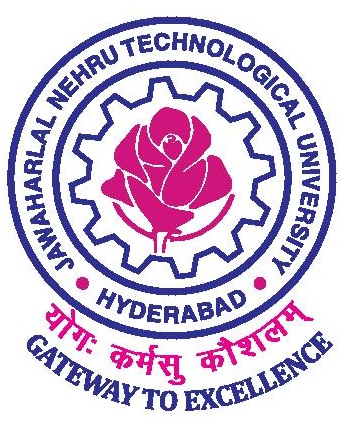
**COURSE STRUCTURE AND SYLLABUS**

**M.Sc ANALYTICAL CHEMISTRY**

**CHOICE BASED CREDIT SYSTEM (CBCS)**



**(With effect from 2015-16 onwards)**

**CENTRE FOR CHEMICAL SCIENCES AND TECHNOLOGY**

**INSTITUTE OF SCIENCE & TECHNOLOGY (Autonomous)**

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**

**KUKATPALLY, HYDERABAD.-500085, TELANGANA**

**CENTRE FOR CHEMICAL SCIENCES & TECHNOLOGY (CCST)**

**COURSE STRUCTURE**

**(W.E.F-2015-16 BATCH)**

**M.Sc ANALYTICAL CHEMISTRY**

**SEMESTER-I**

**I YEAR**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **II semester** | | **Course Title** | **Int. Marks** | **Ext.**  **Marks** | **L** | **P** | **C** |
| 1. | Core Course IV | Organic Chemistry - II | 25 | 75 | 4 | - | 4 |
| 2. | Core Course V | Instrumental Methods of Analysis | 25 | 75 | 4 | - | 4 |
| 3. | Core Course VI | Physical Chemistry-II | 25 | 75 | 4 | - | 4 |
| 4. | Core Elective II | (i) Spectroscopyand spectrometry  (ii) Applied Analysis | 25 | 75 | 4 | - | 4 |
| 5. | Open Elective II | (i) principles of chemical engineering  (ii) Physical Organic Chemistry | 25 | 75 | 4 | - | 4 |
| 6. | Laboratory III | organic Chemistry Lab –I | 25 | 75 | - | 8 | 4 |
| 7. | Laboratory IV | Physical Chemistry Lab-II | 25 | 75 | - | 8 | 4 |
|  | **Total** | | **175** | **525** | **20** | **16** | **28** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **I semester** | | **Course Title** | **Int. Marks** | **Ext.**  **marks** | **L** | **P** | **C** |
|  | Core Course I | Organic Chemistry - I | 25 | 75 | 4 | - | 4 |
|  | Core Course II | Inorganic Chemistry | 25 | 75 | 4 | - | 4 |
|  | Core Course III | Physical Chemistry-I | 25 | 75 | 4 | - | 4 |
|  | Core Elective I | 1. Principles of Analytical Chemistry 2. Bio Molecules | 25 | 75 | 4 | - | 4 |
|  | Open Elective I | 1. Applied Chemistry 2. Computers and mathematics | 25 | 75 | 4 | - | 4 |
|  | Laboratory I | Inorganic Chemistry Lab | 25 | 75 | - | 8 | 4 |
|  | Laboratory II | Physical Chemistry Lab-I | 25 | 75 | - | 8 | 4 |
|  | **Total** | | **175** | **525** | **20** | **16** | **28** |

**II YEAR**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **III semester** | | **Course Title** | **Int. Marks** | **Ext.**  **Marks** | **L** | **P** | **C** |
| 1. | Core Course VII | Quality Management and IPR | 25 | 75 | 4 | - | 4 |
| 2. | Core Course VIII | Separation Methods | 25 | 75 | 4 | - | 4 |
| 3. | Core Course IX | Spectroscopic Methods Of Analysis | 25 | 75 | 4 | - | 4 |
| 4. | Core Elective III | (i) Hyphenated & Other Analytical Techniques  (ii) Medicinal Inorganic Chemistry | 25 | 75 | 4 | - | 4 |
| 5. | Open Elective III | (i) Industrial & Environmental Analysis  (ii) Laboratory Analysis and managment | 25 | 75 | 4 | - | 4 |
| 6. | Laboratory V | Wet Analysis Lab | 25 | 50 | - | 6 | 3 |
| 7. | Laboratory VI | Analytical Instrumentation Lab | 25 | 50 | - | 6 | 3 |
|  | Seminar |  | 50 | - | - | 4 | 2 |
|  | **Total** | | **225** | **475** | **20** | **16** | **28** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **IV Semester** | | **Int. Marks** | **Ext.**  **Marks** | **L** | **P** | **C** |
| 1. | Project Work Review | 50 | - | - | 8 | 4 |
| 2. | Project Evaluation (VivaVove) | - | 150 | - | 16 | 12 |
|  | **Total** | 50 | 150 |  | 24 | 16 |

**SEMESTER-I**

**CORE COURSE –I**

**ACT-101: ORGANIC CHEMISTRY – I**

**UNIT – I**: **Reaction Mechanism-I**

**Addition Reactions**:

Addition to carbon – carbon and carbon-hetero atom multiple bonds – Electrophilic, Nucleophilic and Free radical addition. Stereochemistry of addition to carbon – carbon multiple bonds, orientation and Reactivity.

**Substitution reactions:**

Aliphatic Nucleophilic substitutions – SN1, SN2& SNi mechanism, effects of substrate, attacking Nucleophile, leaving groups and solvent effect, stereochemistry of nucleophilic substitution reactions, substitution at vinyl and allylic carbons, neighboring group participation. Aromatic nucleophilic substitution – mechanism – effects of substrate, structure, leaving group and attacking nucleophilic – aromatic Electrophilic substitution – reactions and mechanism

**Elimination reactions:**

E1, E2, E1CB reactions. Elimination versus substitution reactions, pyrolytic syn eliminations.

**UNIT II: Stereochemistry-I**

**Concept of Chirality:**

Molecular representation of organic molecules Wedge, Fischer, Newman and Sawhorse formulae, their description and interconversion. Stereoisomerism, definition and

Classification of Molecules with Chiral centres.Configurational nomenclature(DL&RS) Geometrical Isomerism – Cis/Trans and E/Z Nomenclature.Introduction to conformational Isomerism, Introduction to Dymamic stereochemistry Eg; Ethane, 1,2 Di-substituted ethane, Butane, Dihalo Butanes, Halo Hydrines, Ethylene Glycol, Butane 2,3 Diol, Amino Alcohols, 1,1,2,2, Tetra halo butanes. Cyclohexane and mono & di-substituted cyclo hexane systems.

**UNIT – III: Heterocycles I:**

Importance of Heterocyclic compounds, classification and nomenclature of hetero cyclic compounds, with one Hetero atom – Furan, Pyrrole, Thiophene and their comparative reactivity.Benzothiophene, Indole, Benzofuran, Pyridine, Quinoline, Isoquinoline, Acridine, Carbazole, Coumarins and Chromones.

**UNIT –IV**

**Carbohydrates and vitamins:** Reactions of monosaccharides .Relative and absolute Configuration of D (+) Glucose and D(-) Fructose. Determination of structure of Sucrose maltose, lactose and cellobiose. Structural features of poly saccharides like cellulose and starch.

**Vitamins:**

classification of vitamins and applications. Synthesis of vitamins A1,B1,B2,B6,C,Biotin and

E.

**UNIT - V**

**a)Reactive Intermediates:**Formation and stability of carbonium ions, carbanions, carbenes, Free radicals, Nitrenes and Arynes

**b)Reaction Intermediates and organic reaction mechanism:**

Energy profile – Transition state – Solvent effects – Use of Isotopes, acid-base catalysis – Crossover experiments. Reactive intermediates:

**c)Molecular rearrangements**

Definition and classification. Molecular rearrangement involving (i) Electron deficient carbons (Wagner – Meerwein, Pinacol-Pinacolone) (ii) Electron deficient Nitrogen (Hofmann, Curtius, Lossen, Beckmann, Schmidt) (iii) Electron deficient Oxygen (Baeyer – Villiger Oxidation). Base Catalyzed rearrangement (Benzillic acid rearrangement, Trans annular rearrangement, Von Richter, Sommlett - Hauser and Smiles rearrangement).

.

**Recommended books:**

1. Stereochemistry of carbon compounds by Ernest L.Eliel and Samuel H. Wilen

2. Stereochemistry of organic compounds- Principles and Applications by D. Nasipuri

3. Heterocyclic Chemistry, T.L. Gilchrist, Longman UK Ltd, London (1985).

4. Benzofurans A. Mustafa, Wiley-Interscience, New York (1974).

5. Heterocyclic Chemistry, 3rd Edn J.A.Joule, K.Mills and G..F.Smith, Stanley Thornes

Ltd,UK, (1998)

6. The Chemistry of Indole, R.J. Sunderberg, Academic Press, New York (1970).

7. An introduction to the chemistry of heterocyclic compounds, 2nd Edn.R.M.Acheson,

Interscience Publishers, New York, 1967.

8. Advanced Organic Chemistry by Jerry March

9. Mechanism and Structure in Organic Chemistry S. Mukerjee

10. Guide Book to mechanism in Organic Chemistry, 6th Edition, Peter Sykes.

11. Organic Chemistry by Graham Solomous and Craig Fryhle.

12. Organic Chemistry by RT Morrison and RN Boyd.

13. Organic Chemistry, Vol. 2 by I.L. Finar.

14. Organic Chemistry: Structure and Reactivity by Seyhan Ege

**SEMESTER-I**

**CORE COURSE –II**

**ACT-102: INORGANIC CHEMISTRY**

**UNIT – I: Coordination and Bio Coordination chemistry**

Crystal Field Theory: d-Orbital Splitting patterns in Octahedral (Regular, Compressed and elongated),Square Pyramidal, Trigonal Bipyramidal, Tetrahedral, square Planar, Trigonal Planar and Linear geometries, Factors influencing the magnitude of Crystal Field Splitting in Octahedral Complexes –Spectrochemical series of ligands - concept of weak and Strong crystal Fields-Calculation of Crystal Field Stabilization Energies (CFSE) in Six and Four –Coordinate Complexes– High Spin – Low Spin - Limitations of CFT Model for Complexes - Experimental Evidence for Metal-Ligand Bond Covalency Thermodynamic aspects of Crystal Field splitting .

**Metal Ions in Biological Systems:**

Brief Survey of Metal Ions in Biological Systems –Effect of Metal Ion Concentration – Basic Principles Underlying Biological Selection of Elements. Oxygen Transport and Storage:Haemoglobin and Myoglobin, Geometric, Electronic and MagneticAspects of Dioxygen Binding, Oxygen Adsorption Isotherms and cooperativity in Haemoglobin and its physiological significance, role of the Globia Chain.

**UNT – II: Coordination Equilibria**

Solvation of Metal Ions –Binary Complexes: Formation of Binary Metal Complexes and their

Stability-Types of Stability Constants: Thermodynamic, Concentration and Conditional Constants –relationship between stepwise and overall stability constants – Trends in Stepwise stability Constants - Factors influencing the Stability Constants: i) Ligand Effects: Basicity, Substituent, Steric, Chelate (Size and Number of Chelate Rings ), Macrocyclic andCryptate Effects ii) Metal Ion Effects : Ionic Potential, Effective Nuclear Charge and Atomic Number (Irving’s –William’s Order, Geometry of Metal Ion and Ligand) Chelate Effect and its Thermodynamic Origin -Jahn –Teller Effect on Stability Constants of Metal Complexes –Pearson’s Theory of Hard and Soft Acids and Bases (HSAB), Applications of HSAB, Electro negativity Vs Hardness and Softness.

**UNIT – III: Reaction Mechanism:**

Energy profiles of reaction - Reactivity of metal complexes: Inert and labile complexes, Concept of Liability and Inertness in terms of valence bond and crystal field theories.

**Nucleophilic Substitution reactions of Octahedral Complexes:**

Dissociative and Associative mechanisms-Mechanistic labels-In gold’s Terminology (SN1 and SN2) Long ford-Gray Terminology-Acid hydrolysis, Factors effecting acid hydrolysis,

Base hydrolysis-conjugate Base mechanism-Evidence in favor of conjugate mechanism. Reactions with- out Metal-Ligand Bond cleavage.

**Nucleophilic Substitution Reactions of Square planar Complexes*:***

Mechanism of substitution in square planar complexes. Evidence in favour of Associative Mechanism –Trans Effect, Theories of Trans effect-Applications of Trans effect.

**Electron – Transfer reactions:**

Inner & outer Sphere Electron Transfer Reaction mechanisms, Marcus-Hush Theory.

**UNIT – IV: Molecular symmetry and Group Theory:**

Basic concepts of Symmetry and group theory-symmetry elements and symmetry operations Schoenflies symbols - Classification of molecules into point groups - Group multiplication Cv, Cn point groups-elementary-symmetry types, functions and classes Representations-reducible and irreducible representations Mulliken symbols, Orthogonal theorem and its implications. Character table and its Anatomy.

**UNIT – V: Metal Clusters**

**Carbonyl Clusters**

Factors favouring Metal-Metal Bonding-Classification of Clusters**.** Structures and bonding in Carbonyl clusters. M4(CO)12 M=Co, Rh, Cr. M3(CO)12 , M=Fe

**Metal halide clusters:**

Major structural types in Dinuclear Metal-Metal systems. Structure and

Bonding in Halides of Mo(II) and Re(III).

**Ligational Aspects of Diatomic Molecules:**

**i**.)Ligational properties of CO:Donor (HOMO) and Acceptor (LUMO) Molecular Orbitals of CO Bonding modes of CO: Terminal and Bridging-Bonding - Classification into mononuclear, binuclear, Trinuclear and Tetranuclear carbonyls. Structures of Ni(CO)4, Cr(CO)9, Mn2(CO)10, Fe2(CO)9 and Co2(CO)8-Eighteen Electron Rule in Metal Carbonyls.

*ii.)*Metal Dinitrogen Complexes:Ligational properties of N2: Donor (HOMO) and Acceptor

(LUMO) Molecular Orbitals of N2-Bonding modes of N2: Terminal and Bridging-Bonding in

dinitrogen complexes- Structure Ru(II) and Os(II).

**Recommended Books:**

1. F.A.Cotton and Wilkinson: Advances in inorganic Chemistry, 1989.

2. J.E.Huheey : Inorganic chemistry, 1983.

3. J.D.Lee :Concise Coordination chemistry.

4. Symmetry & Spectroscopy of Molecules K.Veera Reddy,New Age international Ltd 1998.

5. BioInorganic Chemistry- K.Hussain Reddy

6. Selected Topics in Inorganic chemistry madan,Malik,Tuli S.Chand publications.

7. Inorganic reaction Mechanism- F.Basolo & R.G.Pearson, New York.

8. Inorganic Chemistry- Keith F.Purcell & John C.Kotz Holt- Saunde International Edition.

9. Ligational aspects of diatomic molecules-Organometallic Chemistry R.C.Mehotra.

10. Bio-inorganic Chemistry, Gopalan

11. K.V.Raman,Group Theory and its applications to Chemistry,Tata McGraw Hill

Publishing Co.1990

**SEMESTER-I**

**CORE COURSE –III**

**ACT – 103 PHYSICAL CHEMISTRY – I**

**UNIT- I: Thermodynamics-1**

Brief review of concepts and the I and II laws of Thermodynamics. Concept of entropy-entropy as state function. Entropy changes in various processes. Entropy changes in ideal gas. Entropy change on mixing of ideal gases. Entropy as a function of V & T. Entropy as a function of P& T. Entropy changed in isolated systems - Clausius inequality. Entropy change as criterion for spontaneity and equilibrium.

**Third law of thermodynamics:**

Evaluation of absolute entropies from heat capacity data for solids, liquids and gases. Standard entropies and entropy changes of chemical reactions. Helmholtz and Gibbs energies ( A&G). A&G as criteria for equilibrium and spontaneity. Physical significance of A&G. Driving forces for chemical reactions-relative signs of ΔH & ΔS.

**Thermodynamic relations**:Gibbs equations. Maxwell relations. Temperature dependence of G.Gibbs Helmholtz equation. Pressure dependence of G. Phase equilibrium. Clapeyron equation and Clausus-Clapeyron equation.

**Unit-II: Electrochemistry**

**Ionics:**

Terminology of Conductance, electrolytic conductance, Kohlrausch’s law and its applications ionic equilibria, conductometric titrations.

**Debye – Huckel theory:**Debye – Huckel theory of strong electrolytes, Activity coefficients of electrolytes. The Debye – Huckel limiting law (DHLL)

**Electrodics:**

Types of electrodes, Electrode potentials, electrode reaction-Nernst equation and its derivation. Cell EMF. Reference electrodes, Indicator electrodes, Chemical cells and Concentration cells, with and without transference. Potentiometric titrations-determination of pH and Solubility product from EMF measurements.

**Unit-III: Quantum chemistry**

**Basic Principles:** Black body radiation-Planck`s concept of quantization-Planck`s equation (derivation not required). Photoelectric effect, Hydrogen spectrum. Bohr`s theory and its failures. Wave-Particle duality and uncertainty principle-significance of these for microscopic entities. Emergence of quantum mechanics.

**Operators:**operator algebra. Commutation of operators, linear operators. Complex functions. Hermitian operators. Operators Δ and Δ2. Eigen functions and Eigen values. Degeneracy. Linear Combination of Eigen functions of an operator. Well behaved functions. Normalized and Orthogonal functions.

**Postulates of Quantum mechanics*:*** Physical interpretation of wave functions. Observables and Operators. Measurability of properties.

**UNIT IV: Chemical Kinetics**

**Theories of reaction rates**

Collision theory, steric factor, Transition state theory, Reaction coordinate, Activated complex and the transition state. Thermodynamic formulation of transition state theory. Activation parameters and their significance. The Eyring equation, Unimolecular reactions and Lindamann’s theory. Salt effects.

**Complex Reactions**

Opposing reactions, parallel reactions, consecutive reactions (all first order type). Chain reactions, chain length, Rice Herzfeild Mechanism, explosion limits general Characteristics, Steady state treatment. Ex: H2-Br2 reaction, Derivation of rate law.

**Homogeneous catalysis: Acid base catalysis**

The mechanism of hydrolysis, Specific acid catalysis. General acid catalysis (hydrolysis of ester and vinyl ether). Specific base catalysis and general base catalysis (Aldol reaction and hydrolysis of acetic anhydride),

**Introduction to enzyme catalysis:**Michaeli’s -Menten kinetics.

**UNIT V: Solid State Chemistry**

**Crystalline nature**

Classification. Kinetics of solid state reactions. Crystal defects. Perfect and imperfect crystals. Classification of imperfections. Point defects. Schottky defects. Frenkel defects. Line defects and plane defects. Electron diffraction, Bragg’s law and applications, Band theory, band structure of metals, insulators and semiconductors.

**Superconductivity*.*** Occurrence of superconductivity. Destruction of superconductivity by

magnetic fields-Meisner effect. Types of superconductors. Theories of super conductivity-

BCS theory.

**High temperature superconductors*.*** Structure of defect perovskites. High Tc superconductivity in cuprates. Phase diagram of Y-Ba-Cu-O system. Crystal structure of YBa2Cu3 O7-x. Preparation of 1-2-3 materials. Origin of high Tc superconductivity.

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1. Introduction to chemical thermodynamics – by I.M.Klotz

2. Introduction to chemical thermodynamics – by R.P.Rastogi,R.R.Misra

3. Chemical Kinetics by K.J.Laidler

4. Chemical Kinetics by C.Kalidas or J.C.Kuriakose

5. Quantum Chemistry,R.K.Prasad Wiley Eastren,New Delhi.

6. Quantum Chemistry by D.A.Mc Quarrie,University science books ,Mil valley, california

7. Solid State Chemistry, K.F.Purcell and J.C. Klotz

8. Solid State Chemistry,A.R.West,John Wiley, 1990

**9.**Thermodynamics by J.Rajaram, and J.C.Kuriakose

10.Fundamentals of Quantum chemistry.by R.Anatha Raman,Mcmillan India Ltd,2001.

11. P.W.Attkins,physical chemistry,Oxford University press.

**SEMESTER-I**

**CORE ELECTIVE- I**

**ACT-104.1 PRINCIPLES OF ANALYTICAL CHEMISTRY**

**UNIT-I: Introduction to analytical chemistry**:

Safety in laboratory; Analytical balances – types, care & use, weights and reference mass;

Water for lab use – different grades and methods of purification of water; Reagents and Standard solutions – Expression and units of concentrations, Classification of Errors-Systematic & random errors, identification and reduction of these errors; Significant figures; Qualitative and Quantitative analysis; Statistical functions and reliability of results; Comparison of results – Student’s t-test, F-test & paired-t test.

**UNIT-II: Gravimetric analysis and titrimetric analysis**

**Gravimetry:** Principles of precipitation gravimetry; Nucleation, precipitation, and growth of precipitates; Particle size and filterability of precipitates; Precipitation from homogeneous solution; Co precipitation - impurities in precipitation, Washing, drying, incineration of precipitates; Use of organic reagents in Gravimetric analysis

**Titrimetric Analysis**

Principles underlying titrimetric methods: Primary standards & standards solutions; Equivalence point and endpoint; detection of end point; types of titrations.

**Redox titrations:**

Principle and detection of equivalance point by visual & potentiometric methods. Applications - Use of Jones reductor; Karl Fisher reagent for water determination.

**Complexometric titrations**:

Principles of complexometric titrations, stability constants, Use of EDTA for the determination of metals and practical considerations.

**UNIT-III**: **Quality Management Systems:**

Quality assurance and management systems, elements of quality assurance in analytical laboratory, ISO-9000, 9001 and 9004 systems – purpose, objective and benefits, process approach; ISI and TUV standards.

Good laboratory practices - implementation and organization: Organization and personnel, Study director, Facilities, Equipment, Quality assurance unit, SOPs, Reagents and solutions, Test and control articles, Raw data, Storage and archiving, How to conduct a GLP study, Enforcement of GLP.

Characteristics of an analysis – analytical method development, analytical method validation – sensitivity, specificity, selectivity, accuracy, precision, robustness, ruggedness, limit of detection and limit of quantitation.

**UNIT-IV: Chromatographic techniques -1**

**Fundamentals of chromatographic separation methods –** Definition, Principles of chromatography, sorption mechanisms - differential migration, partition and adsorption phenomena; Classification of different chromatographic methods; Methods of development- Elution development, Gradient elution development, displacement development and frontal analysis. *Dynamics of chromatography*-efficiency of chromatographic column, zone spreading, High Equivalent Theoretical plate (HETP), Van Deemeter equation.

**Column chromatography:**

principles, general aspects, adsorption isotherms, chromatographic media, nature of forces between adsorbent and solutes, eluents, (mobile phase), column chromatography without detectors and liquid chromatography with detectors and applications.

**UNIT-V: Chromatographic techniques -2**

**Paper chromatography:**

principle, papers as a chromatographic medium, modified papers, solvent systems, mechanism of paper chromatography, experimental technique, different development methods-ascending, descending, horizontal, circular spreading, multiple development, two dimensional development, reverse phase paper chromatographic technique visualization and evaluation of chromatograms, applications.

**Thin Layer Chromatography:**

principle, chromatographic media-coating materials, applications, activation of adsorbent, sample development, solvent systems, development of chromatoplate, types of development, visualization methods, documentation, applications in the separation, HPTLC principle, techinique, applications.

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**Recommended books:**

1. Douglas A. Skoog, Donald M. West and F. James Holler, analytical chemistry an

introduction,saunders college publishing, New york, 1990.

2. J. Bassett, R.C. Denny, G. Jeffery and J. Mendham. Vogel’s text book of inorganic

Quantitative analysis, 4th edition, Longman group Ltd, Harlow, 1985.

3. Pietrazyk and Frank. Analytical chemistry, 1990.

4. KVSG Muralikrishna, An Introduction to ISO 14000, Environmental Management, 1998.

5. Y.Anjaneyulu, Quality Assurance and GLP – IGNOU Pub., New Delhi, 1999.

6. Omachonu V.K.and Ross J.E. Principles of Total quality , S.Chand & Co.Ltd., New Delhi,

1997.

7. Werner Funk, Vera Damman, Gerhild Donnervert. Quality Assurance in Analytical

Chemistry,VCH Publishers, New York, NY (USA), 1997.

6. Bertamd L.Hanser and Prabhakar Ghani. Quality Control and Applications, Prentice-Hall

**SEMESTER-I**

**CORE ELECTIVE- I**

**ACT-104.2 BIOMOLECULES**

**UNIT-I: Enzymes:** Definition. Classification based on mode of action. Mechanism of enzyme catalysis. Lock and Key model and Induced- Fit model. Enantiomer discrimination by Three point Contact model. Factors affecting enzyme catalysis. Enzyme inhibition- reversible and irreversible inhibition. Enzymes in organic synthesis. Immobilized enzymes.

**UNIT-II: Nucleic acids:** Primary, secondary and tertiary structure of DNA. Types of mRNA,tRNA and rRNA. Replication, transcription and translation. Genetic code. Protein biosynthesis. Chemical Synthesis of nucleosides and nucleotides.

**UNIT-III: Lipids-Oils and Fats**: Classification, role of lipids, fatty acids and glycerol derived from oils and fats; Physical properties - polymorphism, reactions of fats, rancidity, reversion, polymerisation, saponification, addition, hydrogenation, phospholipids, lipid metabolism; intermediary metabolism of fatty acids, synthesis of fatty acids.

**UNIT-IV: Vitamins:** Classification, distribution in foods, loss during processing, effects of deficiency and characteristic properties of vitamins – B1( Thiamine), B2(Riboflavin), B3 (Pantothenic acid ),B6 (pyridoxine), B12 (Cyanocobalamine), H(Biotin), P(Rutin) C(ascorbic acid), A(Retinol), D(Calciferol), E(Tocopherol), K( naphthoquinone).

**UNIT-V: Introduction to Drugs**

Introduction, Classification, examples of natural and synthetic drugs.

***Chiral drugs:*** Introduction to chiral drugs. Synthesis and pharmacological activity of S-Ibuprofen, S- Metaprolol, Ininavir sulfate, Levocetrazine, 2S-Verapamil, S,S-Ethambutol, (+)Lomefloxacin, Fluvastatin, Dextropropoxyphen, (+)Ephedrine, (+)Griseofulvin, Dexormaplatin, R-Indacrinone, Nateglinide, Oxybutynin hydrochloride, S,S- Captopril and S,S,S- Enalaprilate.

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**Recommended books:**

1. Enzyme structure and mechanism by Fersht and Freeman
2. Bio-Organic chemistry by Hennan Dugas
3. Nucleic acids in Chemistry and Biology by G M Blackbum MI Gait
4. Lehninger Principles of Biochemistry by D L Nelson and M M Cox
5. Outlines of Biochemistry by Conn and Stumpf
6. Biotransformations in Organic Chemistry by K Faber.
7. Principles of biochemistry by Horton & others.
8. Bioorganic chemistry - A chemical approach to enzyme action by Herman Dugas and Christopher Penney.
9. Burger’s medicinal chemistry and drug discovery. By Manfred B. Wolf.
10. Introduction to Medicinal chemistry. By Graham Patrick.
11. Introduction to drug design. By R.B.Silverman
12. Comprehensive medicinal chemistry. Vol 1-5 by Hanzsch.
13. Principles of medicinal chemistry. By William O. Foye etal.
14. Biochemical approach to medicinal chemistry. By Thomas Nogrady.
15. Pharmaceutical Chemistry and Drug synthesis By Roth and Kleeman
16. Drug design By E.J. Arienes
17. Principles of Medicinal Chemistry. Vols.1 & 2 By Kadam etal
18. Medicinal chemistry An introduction By Gareth Thomas

**SEMESTER-I**

**OPEN ELECTIVE- I**

**ACT-105.1: APPLIED CHEMISTRY**

**UNIT-I: Nano materials**

Introduction to Mesoporous materials, Nano-sized materials, Crystal structure, properties of individual Nano particles, Metal Nano Clusters, Preparation techniques like hydrothermal synthesis, sol-gel processes, Hard templating routes, Rf plasma chemical methods, Thermolysis and pulsed laser methods, In situ reduction methods, Carbon nanotubes, fullerenes, their synthesis, characterization & applications, characterization by XRD, TEM.

**UNIT-II:**

**a)Methods of Purification:**

**Distillation**: Basic principles. Distillation types, continuous distillation, batch distillation,

fractional distillation, vacuum distillation and steam distillation. Deans-stork Distillation

and their Industrial applications.

**Drying Techniques**: Drying of Hexane, Benzene, Toluene, Xylene, Tetrahydrofuran,

DMF, DMSO, Methanol, Ethanol, Diethylether, Dioxane

**CrystalizationTechniques:** Different kinds of crystallization, Single crystal generation and analysis of crystal structure.

b) **Industrial safety:**

Introduction, Factors Contributing to the Costs of Accidents, List of some Notable accidents in the process industry/selected case histories. **material hazards**: Introduction Hazards substances-categories, Toxicity, Radiation, Flammability, Ignition, Fires and explosions.

**UNIT-III: Water Technology**

Hardness of water – Temporary and permanent Hardness- units. Desalination of Brackish water- Reverse Osmosis and Electro dialysis. Industrial treatment of water- Lime soda ash method-Chemical reaction- problems- zeolite and ion exchange process. Boiler troubles- scale and sludge formation – Caustic Embrittlement and boiler corrosion- Internal conditioning methods- phosphate and carbonate conditioning- priming and Foaming.

**UNIT IV: Fuel Technology**

Classification of fuels, characteristics of fuels-calorific value units (lower, higher) and its determination-Bomb calorimetric method. Solid fuels - classification of coal, Rank analysis of coal - proximate and ultimate analysis.

Liquid fuels-Introduction, origin of petroleum, classification-mining, refining, cracking (thermal and catalytic), synthesis and purification of gasoline-knocking and octane number of gasoline,Diesel - Cetane number-high speed and low speed diesel oil. Gaseous fuels-biogas, LPG. Analysis of fuel gases.

**UNIT-V: Polymer Chemistry& Engineering Materials**

Types of polymerization –anionic, cationic, free radical, coordinate polymerization ring opening. Types of initiators-Free radical, Anionic,Cationic polymerizations.molecular weight of polymers Mw ,Mn determination osmometry, light scattering basics of kinetics of polymerization.

Preparations and applications of the following

i)polyethylene, polystyrene, polyvinyl chlolride, silicone resins.

ii)synthetic fibres:Nylon 66, Dacron, orlon, Rayon.

iii)Rubbers, Elastomers.

iv)conducting polymers, Biodegradable polymers.

Ceramics-Introduction-Classification – Glazed &Unglazed Ceramics -Properties-**Applications**

Lubricants-Definition and Explanation of Lubrication-Mechanism of Lubrication –Types of

Lubricants -Properties of Lubricants-Engineering applications.

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**Recommended Books:**

1. A Text book of engineering chemistry – S.S.Dara & K.Mukkanti, S. Chand Publications.

2. Applied Chemistry-II, V.M. Balsaraf, I.K.International.

3. Applied Chemistry, H.D. Gesser, Springer.

4. Comprehensive engineering chemistry-Devender singh, Balsaraf, Satish KumarVats,

I.K.International.

5.Chemical process industry safety by K S N Raju, Mc Graw Hill Education, 2014

6. Nanotechnology in Catalysis by Pinzhan

7. Springer Handbook of Nanotechnology by Bharat Bhushan

# 8. Introduction to Polymer Chemistry by Charles E.Carraher.

# 9. Textbook of Polymer Chemistry by Man P Singh.

# 10. Organic Chemistry by   Marye Anne Fox, James K. Whitesell.

**SEMESTER-I**

**OPEN ELECTIVE- I**

**OCT-105.2: COMPUTERS AND MATHEMATICS**

# UNIT-I : Computer basics :Problem solving using computers- flowcharts-algorithms-CPU-Input and output units-.computer memory- Basic concepts of Object oriented Languages Basic structure of C++ programming- tokes-keywords-data types: basic data types-derived data types-user defined data types- constants-variables-arrays-one, two and multi dimensional arrays-structure-union-enumerated data types.

# UNIT-II: Arithmetic operators- relational operators-increment and decrement operators-bit wise operators-arithmetic expression-precedence of operators-Evaluation of expression- type compatibility-expression and implicit conversion-manipulators-control structures: decision making and branching-decision making and looping-Function declaration and definition- argument passing-return values.

# UNIT-III: Class and objects-member functions- array of objects-object as a argument- function overloading- friend function-operator overloading-this pointer-static data member-static member function Constructors: default constructor-parameterized-copy constructor-dynamic constructor-destructors-Inheritance-single inheritance-multiple inheritance-multilevel inheritance-pointers virtual functions and polymorphism

**Unit-IV: Differential Calculus:**

Functions- continuity and differentiability, Rules for differentiation. Sums, products and quotients of functions. The chain rule. Differentiation of algebraic, exponential logarithmic and composite functions. Higher order derivatives. Maxima and minima. Partial differentiation and meaning of total derivative exact and inexact differentials

**Integral Calculus:**

Basic rules for integration. Methods for evaluating integrals-the substitution method, use of partial fractions, integration by parts. Definite integrals.

**UNIT-V: Elementary differential equations:**

First order differential equations- separable variables. Homogenous and linear differential equations. Linear second order differential equations- solutions for homogenous equations.

**Introduction to statistics**

population-sample –primary data and secondary data - graphical and

diagrammatic representation of data- Measure of central tendency-Mean, median and mode measure of dispersion-range-standard deviation . Binomial, Poisson and Normal distribution (definitions statements of properties and examples).

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**Recommended Books:**

# 1) Fundamentals of Computers by V Raja Raman

# 2) Object Oriented Programming with C++ by E. Balagurusawmy

# 3) Statistical methods S.P.Gupta. S Chand Publications

**SEMESTER-I**

**LABORATORY-I**

**ACP – 106: INORGANIC CHEMISTRY LAB**

**Quantitative Analysis:**  Preparation of the following simple inorganic complexes.

a)Tetraamino cu(II)sulphate.

b)Hexaamino Ni(II)chloride

c)Tris Ethylene diammine Ni(II)thiosulphate.

d)mercury tetra thiocyanato cobaltate

e)potassium tri oxalate chromate.

**Preparation of the following chloropentammine cobalt (III) complexes:**

(Co (NH3)5Cl)Cl2,

(Co(NH3)5NO2)Cl2,

(Co(NH3)5ONO)Cl2

1.Estimation of Al+3 by back titration.

2.Estimation of Ni+2 by back titration.

3.Estimation of ca+2 by substitution titration.

4.Estimation of Ba+2 Gravimetrically.

5.Estimation of Ni+2 gravimetrically Ba+2 volumetrically**.**

**SUGGESTED BOOKS**

1. Practical Inorganic Chemistry, G. Marr and B. W. Rockett.

2. Practical Inorganic Chemistry by G.Pass H.Sutchiffe,2nd edn John Wiley & Sons.

3. Experimental Inorganic/Physical Chemistry, M. A. Malati, Horwood Publishing,

Chichester, UK (1999)

**SEMESTER-I**

**LABORATORY-II**

**ACP – 107: PHYSICAL CHEMISTRY-LAB-I**

**Conductometry**

1. Verification of Ostwald’s dilution law – dissociation constant of a weak acid
2. Verification of Debye – Huckel Onsagar equation
3. Conductometric titrations
4. Hydrolysis constants of aniline hydrochloride.

**Potentiometry**

1. Acid-base titration’s using quinhydrone and glass combination electrode
2. Redox tirtrations Fe2+ vs KMNO4 or K2 Cr2 O7
3. Precipitation titrations AgNO3 vs KCl
4. Titration of a mixture of KCl & KI vs AgNO3
5. Hydrolysis constant by E.M.F method

**Adsorption**

1. Adsorption of acetic acid on animal charcoal or silicagel
2. Determination of critical solution temperature of phenol-water system

**Distribution**

1. Distribution of I2 between CCl4 and H2O

**Text Books:**

1. Advanced Practical Physical Chemistry by J.B.Yadav.
2. Basic Practical physical chemistry by V.K.Ahulwalia
3. Practical physical chemistry by B.D.Khosla

**SEMESTER-II**

**CORE COURSE IV**

**ACT–201: ORGANIC CHEMISTRY – II**

**Unit I: Principles of Stereochemistry**

Relative and absolute configuration: Determination of absolute configuration –Racemisation, racemates and resolution techniques: resolution by direct crystallization, diastereomer salt formation, Chiral chromatography and asymmetric transformations. Methods of racemisation. Axial, planar and helical chirality, configurational nomenclature: Atropisomerism, Axially chiral biaryls, allenes, spiranes, ansa compounds and Helically chiral compounds. Conformational diasteromers & enantiomeris, factors affecting conformational stability and conformational equilibrium-attractive and repulsive interactions of cyclic systems.

**Unit II: Pericyclic Reactions**

Definition, Huckel aromaticity, anti-Huckel aromaticity. Electrocyclic, Reactions :conrotation and disrotation..Electrocyclic closure and opening in 4n and 4n+2 systems.Woodward-Hoffmann selection rules for electrocyclic reactions.Conservation of orbital symmetry and orbital symmetry correlation diagrams.Examples of Electrocyclicreactions. cycloaddtion reactions Suprafacial and Antara facial interactions.π2+π2, π4+π4 cyclo additions. Woodward Hoffmann selection rules for cyclo addition reactions.Examples of Cyclo addition reactions. Sigmatropic reactions: 1,j and i,j shifts .suprafacial and Antara facial shifts.selection rules for i,j shifts. Cope, Degenerate cope and claisen rearrangements.

**Unit-III: Photochemistry**

Photo physical processes and photochemical processes. Electronically excited molecules-singletand triplet states. Jablonski diagram. Photochemistry of carbonyl compounds - n– π\*, π – π\* transitions, Norrish type I and Norrish type II cleavages, Peterno-Buchi reactions, rearrangements of α,β,- unsaturated ketones and cyclic hexadienes, photochemistry of P-Benzoquinones, photochemistry of unsaturated system – olefins, cis-trans isomerism and addition acetylenes dimerisation, dienes – photochemistry of 1,3- butadienes (2+2) additions leading to cage structures and photochemistry of cyclohexadienes.

**Unit IV: Formation of C-C and C=C bonds**

-C-C- (Single) bonds : Alkylation importance of enolate ions - Alkylation of ketones – The enamine reaction and Lithium dialkyl cuprates. -C=C- (double) bonds : β elimination reactions. Pyrolytic synthesis, eliminations - Wittig and related reactions. Reactions of unactivated carbon-hydrogen bonds : Hofmann, Loffler, Freytag reaction, Barton reaction.

**Unit V: Heterocyclic Compounds II**

Five and six membered hetero cyclic systems with more than one hetero atom. Synthesis, properties and applications of Pyrazole, Imidazole, Benzimidazole, Oxazole, Thiazole, Iso Oxazole, Triazole, Tetrazole. Pyradazine, Pyrimidine, Pyrazine, Triazine.

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**Recommended Books:**

1. Stereochemistry of carbon compounds by Ernest L.Eliel and Samuel H. Wilen

2. Stereochemistry of organic compounds- Principles and Applications by D. Nasipuri

3. Heterocyclic Chemistry, T.L. Gilchrist, Longman UK Ltd, London (1985).

4. Heterocyclic Chemistry, 3rd Edn J.A.Joule, K.Mills and G..F.Smith, Stanley Thornes

Ltd,UK, (1998)

5. The Chemistry of Indole, R.J. Sunderberg, Academic Press, New York (1970).

6. An introduction to the chemistry of heterocyclic compounds, 2nd Edn.R.M.Acheson,

Interscience Publishers, New York, 1967.

7. Advanced Organic Chemistry by Jerry March

8. Mechanism and Structure in Organic Chemistry S. Mukerjee

9. Guide Book to mechanism in Organic Chemistry, 6th Edition, Peter Sykes.

10. Organic Chemistry by RT Morrison and RN Boyd.

11. Organic Chemistry, Vol. 2 by I.L. Finar.

12. Organic Chemistry: Structure and Reactivity by Seyhan Ege.

13. Pericyclic Reactions by Mukherjee S M

14. Conservation of Orbital Symmetry by Woodward and Hoffmann

15 Photochemistry by C W J Wells

16. Organic Photochemistry by Turro

17. Molecular Photochemistry by Gilbert & Baggo

18. Organic Photochemistry by D Coyle

**SEMESTER-II**

**CORE COURSE V**

**ACT-202: INSTRUMENTAL METHODS OF ANALYSIS**

**UNIT-I: Electrochemical methods of analysis-1:**

**Conductometry:**

Principle, Fundamental equations, measurement of conductance, Conductometric titrations.

**Potentiometry: Direct potentiometry and potentiometric titrations**

Principle, apparatus and technique, potential (emf),Nernst equation, reference electrodes , measurement of potentilal, applications to neutralization, redox, precipitation, complexometric titrations, location of end points, differential titrations, advantages of potentiometric titrations.

**pH metry:** Principle, Instrumentation, The Glass pH electrode – theory, construction, standard buffers, pH titrations.

**UNIT-II: Electrochemical methods of analysis-2:**

Metallic indicator electrodes: Electrodes of first kind, second kind and third kind metallic redox indicator, cell with and without liquid junction, reference electrodes. Ion selective indicators: Membrane indicator electrodes: classification of membranes, properties of ion-selective membrane, Glass membrane electrodes, precipitation electrodes, solid-state electrodes, liquid-liquid electrodes, plastic/ionophore electrodes, coat wire electrodes. Molecular – selective electrode systems: Gas – sensing probes, bio catalytic membrane (enzyme) electrodes: Mechanism of membrane response, the selectivity ratio, Ion selective evaluation methods, interferences – chemical and electrode interferences, applications of ion selective electrodes. Advantages and disadvantages.

**UNIT-III: Polarography and cyclic Voltammety:**

Basic principles, Instrumentation, Polarographic techniques, Application of polarography in quantitative analysis, analysis of mixtures, application to organic compounds, polarography of metal complexes**,** Amperometric titrations.Ac polarography, rapid scan, pulse and square wave polarography, differential pulse polarography (DPP), cyclic voltametry, chronopotentiometry- basic principles, applications and advantages.

**UNIT-IV**: **Chromatographic Techniques -3**

**HPLC:** Theory, Instrumentation - description of the different parts of the equipment, stationary phases (columns), mobile phase, detectors - UV detector, RI detector, Fluorescence detector, Photo Diode Array detector, ELSD, conductometric detector, and electrochemical detector, applications, advantages and disadvantages.

**GC:** Theory, Instrumentation - description of equipment and different parts, columns(packed and capillary columns), detector specifications –thermal conductivity detector, Flame ionization detector, electron capture detector, nitrogen-Phosphorous detector, photo ionization detector, programmed temperature gas chromatography, applications in the analysis of gases, petroleum products etc.

An introduction to **GC-MS** and **LC-MS** techniques

**UNIT-V: Diffraction Techniques**

I) **X- ray diffraction**: crystal structure, miller indices, Bragg’s equation, Structural analysis of crystals, powder diffraction, NaCl & KCl crystal structures.

II) Fundamentals of **Electron diffraction techniques**

III) Fundamentals of **Neutron diffraction techniques.**

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**Recommended books:**

1. R.A.Day & A.L.Underwood, Quantitative analysis, Prentice-Hall of India Pvt. Ltd., 1985.

2. Skoog & West, Fundamentals of Analytical Chemistry, 1982.

3. Hobert H.Willard, D.L.Merrit & J.R.J.A.Dean, Instrumental methods of analysis, C.B.S

Publishers and Distributors, 1992.

4. Vogel, Textbook of quantitative inorganic analysis, 1990.

5. Ewing, Instumrntal Methods of Analysis, 1992.

6. Instrumental Methodology of Analysis by Chatwal Anand.

**SEMESTER-II**

**CORE COURSE VI**

**ACT-203: PHYSICAL CHEMISTRY –II**

**UNIT- I: Thermodynamics-II**

**Ideal solutions:** Thermodynamics properties of ideal solutions. Mixing quantities. Vapour pressure- Raoult`s law. Thermodynamic properties of ideally dilute solutions. Vapour pressure-Henry`s law.

**Non ideal systems**.Concept of fugacity, fugacity coefficient. Determination of fugacity. Nonideal solutions. Activity and activity coefficients. Standard-state conventions for Nonideal solutions. Excess functions and their determination.

**Statistical thermodynamics:**The distribution of molecular states-configurations and weights, The dominating configuration.Boltzmann distribution; Kinetic theory of gases. The molecular partition function, its interpretation and their relations to thermodynamic quantities, Sucker-Tetrode equation- calculations for model systems.

**Unit-II: Polymers**

Classification of polymers. Types of polymerization. Kinetics and mechanism of free radical polymerization. The crystal structure of polymers. Morphology of crystalline polymers. Crystallization and melting. The glassy state – glass transition temperature Tg of polymers.

Molecular weight distribution – measurement of molecular weights by osmometry

Smart materials – their uses in sensing devices and communication networks. Conducting polymers. Electrically conducting polymers and their uses

Ionic exchange polymers. Cationic and anionic exchange polymers and their uses. Eco-friendly polymers.

Membrane separation. Liquid separation – dialysis, electro osmosis and reverse osmosis.

**UNIT-III: Photochemistry**

Photo physical processes and photochemical processes. Electronically excited molecules-singletand triplet states. Jablonski diagram. Radiationless transitions-internal conversion and intersystem crossing. Fluorescence emission and Phosphorescence emission. Quantum yield and determination.

Photochemical reactions with high and low quantum yields-examples. Transfer of excitation

energy-Sensitization and quenching. Stern – Volmer equation

**Reaction mechanisms**- Cis-Trans isomerization, Norrish Type I Type –II reactions.

**UNIT IV: Surface chemistry**

**Study of surface**– Langmuir and BET absorption isotherms-study of kinetics of surface reactions catalysis by metals, semiconductor oxides-mechanism of heterogeneous catalytic reactions-the absorption coefficient and its significance.

**Heterogeneous Catalysis:**Catalytic activity at surfaces, Adsorption and catalysis – Eley-Rideal Mechanism, Langmuir-Hinshelwood mechanism. Examples of heterogeneous catalysis – Hydrogenation, Oxidation, Cracking and reforming.

**Colloids:**Types, preparation, Characterization of colloids. Colloids in industry.

**UNIT V: Quantum Chemistry-II**

Particle in a box- one dimensional and three dimensional. Plots of y and y2-discussion. Degeneracy of energy levels. Comparison of classical and quantum mechanical particles.

Calculations using wave functions of the particle in a box-orthoganality, measurability of

energy, position and momentum, average values and probabilities. Application to the spectra

of conjugated molecules.

Cartesian, Polar and spherical polar coordinates and their interrelations

*Schrodinger equation for the hydrogen atom*- separation into three equations. Hydrogen like

wave functions. Radial and angular functions. Quantum numbers n, l and m and their importance. The radial distribution functions. Hydrogen like orbitals and their representation.

Polar plots, contour plots and boundary diagrams.

*Many electron systems.* Approximate methods. The variation method-variation theorem and

its proof. Trial variation function and variation integral. Examples of variational calculations.

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1. Advanced Physical Chemistry Gurdeep Raj, Goel Publishing House, Meerut

2. Introduction to chemical thermodynamics – by R.P.Rastogi,R.R.Misra

3. Chemical Kinetics by K.J.Laidler

4. Physical Chemistry, G.M. Barrow, Mc GrawHill

5. Quantum Chemistry,R.K.Prasad Wiley Eastren,New Delhi.

6. Quantum Chemistry by D.A.Mc Quarrie,University science books ,Mil valley, california

7. Solid State Chemistry, K.F.Purcell and J.C. Klotz

8. Solid State Chemistry,A.R.West,John Wiley

9. Physical Chemistry, P.W.Attkins,Oxford University press.

10. Physical Chemistry, R.P.Varma, Pradeep, Jalandhar.

11. K.K.Rohatgi Mukherjee,Fundamentals of PhotoChemistry,Wiley Eastern Ltd.,1978.

12. N.J.Turro, Modern Molecular Photochemistry,Benjamin,Cumrings,Menlopark, California

13. S.Glasstone, Introduction to Electrochemistry,Affliated East West Press,New delhi

14. Principles of Physical Chemistry by Maron & Prutton

15. Engineering Chemistry, C.Parameswara Murthy, C.V.Agarwal and A. Naidu, B.S.

Publications, Hyderabad

**SEMESTER-II**

**CORE ELECTIVE II**

**ACT – 204.1: SPECTROSCOPY and SPECTROMETRY**

**UNIT-I: UV-Visible Spectroscopy**

Spectrophotometry & Colorometry: Introduction, electromagnetic spectrum, units of wavelength,frequency and wavenumbers , the absorption laws ,Absorptivity ,Beer–Lambert’s law Apparent deviations from Beer’s law – Instrumentation –Visual comparative methods, Colorimeters, Single, Double beam spectrophotometer .Sources of radiation – Detectors ––photometric accuracy, Chemical applications – Quanitative analysis –Mixture analysis– photometric titrations

Origin and theory of UV spectroscopy, Types of electronic transitions in organic & Inorganic molecules. Chromopores, auxochromes, Applications of UV spectroscopy to simple organic molecules like conjugated dienes, trienes,unsaturated carbonyl compounds and aromatic compounds.woodward-Fieser rules.

**UNIT-II: Infrared Spectroscopy and Raman Spectroscopy**

Range & Nomenclature of IR ,Theory of IR spectroscopy,modes of vibration ,different types of vibration, Characteristic group frequencies: Alkanes, Alkenes, alkynes, cyclo alkanes and alkyl groups Aromatic compounds, alcohols, phenols ethers, cyclic ethers, amines, compounds containing carbonyl group, carboxylic acids, esters and lactones, anhydrides, nitro, nitroso and nitriles. Factors influencing vibrational frequencies, Instrumenation of IR Spectrophotometer

**Raman Spectroscopy*-*** Quantum theory of Raman effect, Rotational raman and Vibrational

Raman spectra, Stokes and anti- Stokes lines. Complementary nature of IR and Raman

spectra.

**UNIT-III: Microwave Spectroscopy**

Classification of molecules based on moment of inertia. Diatomic molecule as rigid rotator and its rotational energy levels. Selection rules (derivation not required). Calculation of bondlengths from rotational spectra of diatomic molecules. Isotope effect on rotational spectra. Calculation of atomic mass from rotational spectra. Brief description of microwave spectrometer.

**UNIT-IV: Nuclear Magnetic Resonance Spectroscopy**

Principles of Magnetic resonance, Resonance condition, Magnetic Moment & spin angular momentum, Larmor frequency, Proton Magnetic Resonance, Shielding Constants, chemical shifts, factors influencing chemical shifts, solvent shifts, Shielding & Deshielding phenomena, spin-spin coupling, coupling constants.

AX,AX2,AX3,AMX & AB Types of spectra, Methods of simplifying complex spectra. Double resonance technique, dueterium exchange, shift reagent, applications of PMR in structural determination-alcohols, amines, hydrogen bonding, keto-enol tautomerism.

**UNIT-V: Mass Spectrometry**

Basic principles, instrumentation, Types of fragmentation, Nitrogen rule, isotope peaks, common mass fragmentation patterns of organic compounds. Fragmentation patterns of simple hydro carbons, alkyl alcohols, alkyl halides, aldehydes, ketones, aromatic compounds. Origin of meta stable ions and their uses, methods of ionization, electron ionization, chemical ionization, field ionization. Applications to inorganic systems. Structural elucidation of organic compounds by combined application of the spectral methods (IR, UV, 1H, 13C NMR and MS)

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1. W.Kemp, Organic Spectroscopy, 3rd edition, ELBS, Mc Millan, London, 1991.

2. P.S.Kalsi, Spectroscopy of Organic Compounds, 4th edition, New Age International (P)

Ltd.,Publishers, Hyderabad – 29.

3. D.H.Williams and I.Flemming, Spectroscopic methods in Organic Chemistry, 4th edition,

Mc Graw Hill, New York, 1989.

4. C.N.Banwell and E.M.Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition Tata

Mc Graw Hill, New Delhi, 1995.

5. I.Howe, D.H.Williams and R.D.Bowen, Mass Spectroscopy, Principles and Applications,

2nd edition, Mc Graw Hill, London, 1981.

6. C.Djerassi, Optical Rotatory Dispersion.

7. Harald Gunther, NMR Spectroscopy, 2nd edition, John Wiley & Sons (1996).

8. NMR in chemistry-A multi nuclear introduction -William Kemp.

9.Spectroscopic identification of organic compounds by RM silverstien,G.C.Bassler and T.B.

morril

**SEMESTER-II**

**CORE ELECTIVE II**

**ACT-204.2: APPLIED ANALYSIS**

**UNIT-I : Data Handling**

Accuracy, Precision, Types of errors – determinate and indeterminate errors, minimization of

determinate errors, statistical validation- statistical treatment of finite data ( mean, median, average deviation, standard deviation, coefficient of variation and variance), significant figures – computation rules, comparision of results – student’s t-test, F-test, statistical Q test for rejection of a result, confidence limit, regression analysis – method of least squares, correlation coefficient, detection limits. Calculations.

**UNIT-II: Analysis of Air and Water Pollutants**

Air quality standards, sampling, analysis of air pollutants-SO2 (UV\_Vis, IR), H2S (Spectrophotometry and Non-dispersive IR Spectrophotometry), NO-NOx (Chemiluminescence technique, Colorimetric technique- Saltzman method), CO & CO2 (IR,

AAS & GC), Hydrocarbons ( GC, GC-MS), Aromatic hydrocarbons in automobile exhaust, petrol, air, O3 (Chemiluminiscence & Spectrophotometry), particulate matter analysis. Objectives of analysis, sampling, preservation and pre-concentration methods, physical analysis - colour, odour, temperature, pH, EC, redox potential, total desolved solids (turbidimetry), Chemical analysis of anions – CN-, Cl-, F-, NO2-, NO3- (spectrophotometry),

SO4, PO4. Determination of BOD,COD, TOC & DO Analysis of Toxic Metals: Hg, As, Pb, Cd, Be, Al, Cr (Atomic Absorption Spectroscopy and Spectrophotometry)

**UNIT-III: Clinical and Pharmaceutical Analysis**

**Clinical Analysis:** Determination of (1) Serum Calcium (2) Serum/Plasma Bicarbonate (Titrimetry). Determination of Serum Chloride (Coulometry) - Determination of (1) Cholesterol (2) Total Protein (3) Blood Urea in Serum (4) Amylase (5) Aspartate Amino

Transferase (AST) and Alanine Amino Transferase (ALT) (by Spectrophotometry). Determination of (1) Thyroxin and (2) Thyroid-Stimulating Hormone (TSH) ( by RIA Method)

**Pharmaceutical analysis**: Determination of Diclofenac (non-aqueous titration), Calcium in Vitamin D and Calcium formulations (Complexometry), Sulphanilamide (potentiometry),

Pethidine hydrochloride (UV-Vis), Frusemide (UV-Vis), Aspirin, paracetamol and codein in APC tablets (NMR), Phenobarbitone in tablets (IR), pivolic acid in dipivefrin eye drops (GC), Assay of hydrocortisone cream. (HPLC). Impurity profiling of Propranolol (GC-MS), famotidine (LC\_MS).

**UNIT-IV: Food Analysis**

**Food Analysis**: Analysis of Chemical Additives in foods : Division of colour additives, Chromatographic identification of colours, and quantitative estimation of added dyes in foods (Titanium Trichloride Method) - chemical preservatives and synthetic sweetening agents Organic-ether extractable and Non-ether extractable) - Analysis of SO2 & Sodium Benzoate (Chemical Methods), Sorbic Acid (Chromatography) - Types of Antioxidants used in Foods, Analysis of Butylated Hydroxy Toluene (BHT) (Spectrophotometry).

**UNIT-V Agricultural Analysis**: Analysis of soils for available Major Nutrients - Estimation of available Nitrogen (Kjeldahl Method), Phosphorus (Olsen’s Method and Bray and Kurtz Method), and Exchangeable Calcium & Magnesium (by EDTA). Soil analysis for Micronutrients - Estimation of Available Zinc, Copper, Manganese and Iron (AAS)- Analysis of Pesticide Residues - Determination of Methyl Parathion Residues in food grains & vegetables (Solvent Extraction and Titrimetry) - Determination of Organochlorine pesticides by Gas Chromatography (Cypermethrin) - Determination of Malathion and DDT Residues in food grains (Spectrophotometry).

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**Recommended books:**

1. Analytical Chemistry, Gary Christian, VI Ed, John Wiley & Sons Inc, New York.

2. Fundamentals of Analytcal Chemistry, Skoog & West.

3. Pharmaceutical Drug Analysis, Ashtoshka.

4. Vogel’s Text Book of Quantitative Chemical Analysis, 6th Ed, Pearson Education Ltd.

5. Environmental Pollution Analysis, S M Khopkar, Wiley Eastern Ltd 1995.

6. Environmental Analytical Chemistry, F W Fifield, P J Haines, Blackie Academi Professional.

7. Environmental Chemistry, B K Sharma, Goel Publishing House, Meerut.

8. Handbook of Analysis and quality control for fruit and vegetable products, S

Ranganna, Tata Mc Graw Hill Publishers Ltd, 1986.

9. Introduction to chemical analysis of foods, S Suzanna & Nielsen, CBS Publishers & Distributors.

10.Practical pharmaceutical Chemistry, a H Beckett and J B Stenlake, III Ed, Vol I

and Vol II, CBS Publishers & Distributors,1997.

11.Pharmaceutical Analysis, David G Watson,Churchill Livingstone Harcourt Brace

and Company Ltd, 1999.

12.Handbook of analysis of drugs, Nagavi.

13.Medical Laboratory Technology – Mukherjee , Tata Mc Graw Ltd 1988.

14.Medical Laboratory Technology – Ramnik Sood , Jaypee Brothers Ltd 1999.

15. Text Book of Clinical Chemistry V Edn Carl.A. Burtis Edward R. Ashwood Saunders Harcourt India 2001.

**SEMESTER-II**

**OPEN ELECTIVE II**

**ACT-205.1: PRINCIPLES OF CHEMICAL ENGINEERING**

**UNIT- I: Process calculation & Thermodynamics:**

**Chemical Engineering Concepts: Units** and dimensions, Stoichiometric principles, Law of Conservation of Mass, Material Balance with and without chemical reactions. Laws of thermodynamics, equilibrium, phase rule.

**UNIT-II: Fluid Mechanics & Mechanical operations:**

**Fluid flow:** Newton’s law of viscosity, classification of fluids, Hydrostatic Pressure, Manometers, Continuity equation. Bernoulli’s equation and its application, measurement of flowing fluids using orifice meter, Venturi meter and Rota meter.

**Size reduction**: Laws of crushing, various types of crushers and grinders-filtration concepts.

**UNIT-III: Heat Transfer**

Steady state heat transfer-Fourier’s law, modes of heat transfer, simple numerical problems on conduction, natural and forced convection, heat transfer equipment, types of heat exchangers, evaporators, radiation: black body radiation

**UNIT-IV: Mass Transfer**

Classification of mass transfer operations, choice of separation method, molecular diffusion, estimation of diffusivity of gases and liquids, theories of mass transfer, Distillation: Raoult’s law, vapor-liquid equilibria, relative volatility, distillation methods, azeotropic distillation. Basic principles of absorption, adsorption, extraction (qualitatively)

**UNIT-V: Chemical Reaction Engineering**

Overview reaction of chemical reaction engineering, classification of reactions, variables affecting the rate of reaction, definition of reaction rate, concentration dependent term of rate equation, Temperature dependent term of rate equation, Theories of Reaction rates, kinetics of homogeneous reactions, types of reactors -Classification of reactors.

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**Recommended Books**:-

1. W.C.Mccabe and J.C.Smith and peter Harriott, Unit operations of Chemical Engineering.

2. Introduction to Chemical Engineering by Ghoshal & Sanyal,Tata Mc-Graw Hill

3. Levenspiel, O.,“Chemical Reaction Eng “ 3rd ed. John Wiley & sons 2001.

**4.** W.L.Badger and Banchero, Introduction to Chemical Engineering, Mc Graw Hill Book Co.

Inc Kogakusha ,1988.

**SEMESTER-II**

**OPEN ELECTIVE II**

**ACT-205.2: PHYSICAL- ORGANIC CHEMISTRY**

**UNIT-I: Molecular Orbital (MO) and Valence Bond (VB) theory of reactivity**

Introduction to Huckel molecular orbital (MO) method as a means to explain modern theoretical methods. Advanced techniques in PMO and FMO theory. Molecular mechanics, semiemperical methods and ab inito and density functional methods. Scope and limitations of several computational programmes. Quantitative MO theory-Huckel molecular orbital (HMO) method as applied to ethane energy levels .Orbital symmetry, orbital interaction diagrams. MO of simple organic systems such as ethane, allyl, butadiene, methane and methyl group. Conjugation and hyperconjugation. Aromaticity. Valence bond (VB) configuration mixing diagrams. Relationship between VB configuration mixing and resonance theory. Reaction profiles. Potential energy diagrams. Curve crossing model nature of activation barrier in chemical reactions.

Principle of reactivity Mechanistic significance of entropy, enthalpy and Gibbs free energy.

Arrhenius equation, transition state theory. Uses of activation parameters, Hammonds postulate. Bell-Evans-Polanyi principle. Potential energy surface model. Marcus theory of electron transfer. Reactivity and Selectivity principles

**UNIT-II: Kinetic,isotopic, structural effects**

Theory of isotope effects, Primary and secondary kinetic isotope effects. Heavy isotope effects. Tunneling effect Solvent effects. Structural effects on reactivity: Linear free energy relationship (LFER.). The Hammett equation, substituent constants, theories of substituent effects. interpretation of σ-values. Reaction constant ρ. Deviations from Hammett equation. Dual— parameter correlations, inductive substituent constant The Taft model, σ1,σR scales.

**UNIT-III: solvent, steric and conformational effects**

Solvation and solvent effects: Qualitative understanding of solvent- solute effects on reactivity Thermodynamic measure of solvation. Effects of solvation on reaction and equilibrium. Various empirical indexes of solvation based on physical properties, solvent- sensitive reaction rates, spectroscopic properties and scales for specific solvation. Use of solvation scales in mechanistic studies. Solvent effects from the curve-crossing model. Various type of steric strain and their influence on reactivity. Steric acceleration. Molecular measurements of steric effects upon rates. Steric LFER. Conformational barrier to bond rotation-spectroscopic detection of individual conformers. Acyclic and monocyclic systems. Rotation around partial double bonds. Winstein- Holness and Curtin-Hammet principle.

**UNIT-IV:: Nucleophilic, electrophilic and free radical reactivity**

Bases, nucleophiles, Electrophiles and Catalysts. Acid-base dissociation. Electronic and

structural effects, acidity and basicity. Acidity functions and their applications. Hard and soft

acids and bases. Nucleophilicity scales, Nucleofugacity. The α-effect.- Ambivalent nucleophiles. Acid-base catalysis. Specific and general catalysis. Bronstéd catalysis. .nucleophilic and electrophilic catalysis. Catalysis by non-covalent binding micellar catalysts. Nucleophilic and electrophilic Reactivity:Structural and electronic effects on SN1 and SN2 reactivity. Solvent effects,kinetic isotope effects. Intramolecular assistance. Electron transfer nature of SN2 reaction. Nuclcophilicity and SN2 reactivity based on curve-crossing model. Relationship between polar and electron transfer reactions. SRN1 mechanism. Electrophilic reactivity, general mechanism. Kinetics of SE2-Ar reaction, Structural effects on rates and selectivity. Curve crossing approach to electrophilic reactivity.

Radical and pericyclic reactivity. (a)Radical stability, polar influences, solvent and steric effects. A curve crossing approach to radical addition, factors affecting barrier heights in additions, regioselectivity in radical reactions. Reactivity, specificity and periselectivity in pericyclic reactions.

**UNIT-V:: Supramolecular chemistry**

Properties of covalent bonds- bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarisability, bond dissociation enthalpy, entropy. Intermolecular forces, hydrophobic effects. Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects, Hydrogen bond. Principles of molecular association and organization as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model systems like micelles and vesicles. Molecular receptors and design principles. Cryptands, cyclophanes, calixeranes, cyclodextxins. Supramolecular reactivity and catalysis. Molecular channels and transport processes. Molecular devices and nanotechnology.

**Recommended books:**

1. Molecular mechanics. By U.Bukert and N.L.Allinger, ACS Monograph 177,1982

2. Organic Chemistry book of Orbitals. L.Salem and W.L.Jorgenson

3. Mechanism and theory in Organic Chemistry, T.M.Lowry, K.C.Richardson, Harper and Row

4. Introduction to theoretical Organic Chemistry and molecular modeling by W.B.Smith,

VCH,Weinhein.

*5.* Physical Organic chemistry, N.S.Isaaçs

6. Suprarnolecular Chemistry - concepts and perspectives by J M .Lehn,

7. The Physical basis of Organic Chemistry by H.Maskill.

8. Physical Organic Chemistry by Jack Hine

**SEMESTER-II**

**LABORATORY III**

**ACP-206: PHYSICAL CHEMISTRY LAB-II**

**Chemical Kinetics:**

1. Hydrolysis of methyl acetate using HCl at two different strengths and compare the relative

strengths of the acid.

2. Hydrolysis constant of urea hydrochloride-ester hydrolysis method.

3. Study of saponification of ethyl acetate by NaOH conductometrically and determination of

rate constant.

4. Kinetics of persulphate (S2O2-8) and I- reaction

**Overall order**

1. Order with respect to (I-)

2. Order with respect to (S2O8 )-2

3. Effect of salt (KCl ) on the rate of the reaction.

4. Effect of temperature on rate - determination of energy of activation.

**Spectrophotometer**

1) Composition and stability constants of complex ions

2) Verification of Beer’s Law for Kmno4 and CuSo4 solutions

**PH metry**

1) Calibration of PH meter

2) Acid Base Titrations

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**Recommended Books:**

1. Advanced Practical Physical Chemistry by J.B.Yadav.
2. Physical chemistry lab manual by V.KAhulwalia
3. Practical physical chemistry by B.D.Khosla

**LABORATORY IV**

**ACP-207: ORGANIC CHEMISTRY LAB-I**

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**Qualiitative organic analysis – identification of a single substance of at least eight compounds.**

1. Hydrocarbons, Nitro and Halo compounds
2. Carbohydrates
3. Phenols
4. Amines
5. Carbonyl compounds
6. Acids
7. Esters

**synthesis of Organic molecules – one stage preparations of the following.**

a) Benzoin

b) Tribromo aniline

c) M-dinitro Benzene.

d) 4-methyl umbellipherone

e) 2-phenyl indole.

f)Anthracene-Maleic anhydride adduct

**SEMESTER III**

**CORE COURSE VII**

**ACH-301 Quality Management and Intellectual Property Rights**

**UNIT-I Principles & Terminology in QA:**

**Principles & Terminology**: standard-Primary standard; standard solution, Calibration standard, check standard, *Blank:* Reagent blank, Method blank, Calibration blank, Instrumental blank, Process blank, Field blank, Equipment blank.

**Calibration:**Internal standardization, external standardization, addition method, control

sample, dry weight, Duplicate, Duplicate samples, replicate weight.

**Sampling:** Basics of Sampling, Purpose of sampling ,homogeneous and heterogeneous samples, statistical criteria for good sampling ,sample size, sampling unit, gross sample, laboratory sample, Types of Samples, Representative Sample, Selective Sample, Random Sample, Composite Sample, The Sampling Plan, Legal and Statutory Requirements, Types of Sampling, Sample Numbers and Sample Size, Sampling Uncertainty, Number of Primary Samples, Sub-sampling, Sub-sampling Procedures, Sample Handling and Storage, Holding Time.

**UNTI-II Quality Assurance –I**

**Quality control**: Quality control charts, the X-quality control chart, the R-quality control chart and its interpretation, spiked sample control charts, use of blind samples in quality control, use of proficiency evaluations in quality control, Analysis of standard reference materials, Analysis of duplicates.

**Analytical Methods**:Choosing the methods – standard methods, official methods, literature methods. Validation of new methods – Comparison of analytical methods, ruggedness testing of methods, writing analytical methods, modification of analytical methods.– ICH guidelines for method validation, Comparison of analytical methods, ruggedness testing of methods, ‘Sign-off’ and Documentation

**UNIT – III Quality Assurance –II**

**Documentation for quality assurance.**: Documentation, Quality Manual, Supporting Documentation, Record Management, Records, Generating Records, Record Identification, Document and Record Control, Reporting Results, Copying Records, Storing and Archiving Records.

General Reagents and volumetric reagents, sample labelling, sample log-in/register, sample analysis, reporting, recording and personal training. Instrument calibration and maintenance. Analytical report. Personal, training, records-professional, personnel, technician personnel. Filing quality assurance documentation.

**UNIT-IV Quality Accreditation**

Need for laboratory accreditation .International aspects of laboratory accreditation and in India, Criteria for laboratory accreditation, Benefits of laboratory accreditation, The Management System, The Benefits of a Management System, Types of Management Standards for Laboratories, Standards Available for Laboratories, Features of ISO 9001:2008, Features of ISO/IEC 17025:2005, Features of ISO 15189:2003. Significance of ISO 9001, 9002, 9003, 9004, Requirements, ISO/IEC 17025 Requirements, ISO 9001 Requirements, Quality Manual and other Documentation

**UNIT-V Intellectual Property Rights**

Definition, scope and different forms of IPR. Patents, definition, types, contents of patent, claims and types of claims, requirements for patenting, restrictions and the power of patents.

**Recommended books:**

1. Principles of instrumental Analysis – Sixth edition-skoog, Hooller, Nieman

2. Analytical chemistry – Gary D.Christian, Sixth edition, John Wiley and sons. Inc, New

York 1994.

3. Quality Assurance in Analytical Chemistry, B.W.Wenclawaik, Springer, India, 2004.

4. What everyone should know about patents by N.Subbaram – Pharma Book Syndicate

5. Principles of Analytical chemistry – M.Valcarcel.

6. R.A Day A.C Underwood Qualitative analysis

7. Handbook of Quality Assurance for the analytical chemistry laboratory, James.P.Dux, Van

Nostrand Reinhood, New York, 1986.

8. Training Manuals on ISO 9000 PQM, Giridhar, Raj Publishing House, 2001

9. How to Practice GLP,PP Sharma ,vandana Publictions ,2000,New Delhi.

10. Applying ISO-9000 Quality Management systems,Intrnational Trade Centre

publishing,UNCTAD/WTO.Geneva,Switzerland,Indian Edition Printed by D.L.Shah Trust

**SEMESTER-III**

**CORE COURSE VIII**

**ACT-302 SEPARATION METHODS**

**UNIT-I Solvent extraction:**

Principles and processes of solvent extraction, Distribution Law and Partition coefficient Nature of Partition forces, different types of Solvent extraction systems-Batch extraction ,Continuous extraction, Counter current extraction , solvent extraction systems, applications in metallurgy ,general applications in analysis and pre-concentration , special extraction systems like crown ethers, Super fluid and surfactant extractions-examples. Organic reagents as extraction reagents – acetylacetone, thionyl trifluoroacetone, tri-n-octyl phosphine oxide.

**UNIT-II Liquid-Liquid partition Chromatography:**

Principle supports, partitioning liquids, eluents, reverse phase chromatography, apparatus, and applications.

**Flash Chromatography** –

Packing of column, selection of solvent, loading of sample

Dry column flash chromatography - Packing of column, selection of solvent, loading of sample Medium pressure liquid chromatography (MPLC) – Apparatus, Packing of column, selection of solvent, loading of sample

**UNIT III Size Exclusion Chromatography:**

Principles of gel – filtration Chromatography,

Instrumentation, retention behavior, resolution, selection of gel type, applications, structure ofzeolite crystals, applications. Ion exclusion – principle and applications.

**Capillary electrophoresis:** principle, details of the instrument, Applications to Inorganic and

Organic compounds.

**UNIT-IV Ion -exchange chromatography**

Ion -exchange resins, structure of resins. Ion exchange equilibria, selectivity, ion exchange chromatography with reference to anions and cations, applications separation of rare earth metal ions, Amino acid analysis, purification of water for laboratory and industrial use, deionized water.

**Inorganic molecular sieves :** structure of Zeolites,crystals,types of sieves,applicationin the separation of gases including hydrocarbons,ion exclusion- principles and applications,

**Counter current chromatography**- principles and application, **Affinity chromatography**- principles and applications.

**UNIT-V Other methods of separation**

**Supercritical Fluid Chromatography (SFC)**

Instrumentation of SFC, stationary and mobile phases used in SFC, Detectors, Advantages of SFC. Applications, technique and applications of SFC.

**Membrane separations**

Reverse osmosis for water purification, electro dialysis, electro-membrane processing, liquid membranes. Flotation techniques: Froth flotation, Ion flotation. Molecular sieves, clatharates. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Recommended books:**

1. Separation methods by M.N.Sastri,Himalaya Publishing Company,Mumbai.

2. Principles of Instrumental Analysis – Skoog, Holler, Nieman.

3. J.A Dem Separation methods

4. R.P.W.Scott,Techniques and practice of chromatography,Marel dekker Inc.,New York.

5. Analytical Chromatography by Gurdeep R Chatwal

6. Analytical chemistry by Gary D.Christian

7. Vogal Textbook of Quantitative inorganic Analysis.

8. H.M.Mc Nair and J.M. Miller,Basic Gas Chromatography,John Wiley ,New York.

9. E.Helfman, Chromatography, Van Nostrand, Reinhoid, New York.

10. Chemical separation methods,John A Dean,Von Nostrand Reinhold, New York.

**SEMESTER-III**

**CORE COURSE IX**

**ACT-303: SPECTROSCOPIC METHODS OF ANALYSIS**

**UNIT-I: UV and visible spectroscopy** & **Nephelometry and Turbidimetry**

**UV and visible spectroscopy**

Quantitative aspects of absorption measurements-Beer Lamberts law, limitations of Beer’s law, Numerical problems based on Beer’s law, simultaneous spetrophotometry. Shapes of UV-absorption curves, solvent effects on UV-absorption bands, Instrumentation, radiation sources, Mono chromators, Detectors, Recording of the spectra, Applications in Qualitative & Quantitative analysis. Applications in transition metal complexes – Types of transition metal complexes, d-d LMCT and MLCT transitions. Band widths and shapes-nature of electronic transitions – electronic spectra-Band widths and shapes. Factors affecting Band widths.

**Nephelometry and Turbidimetry**

Turbidity of fine particle dispersions, measurement of light scattering dispersions, Qualifications of prepared dispersions for practical turbidimetry or Nephelometric, Turbidometric titration’s, Analysis for impurities in standard grade – chemicals.

**UNIT-II: IR and Raman Spectroscopy**

**Infrared Spectroscopy:**

Instrumentation, radiation sources, monochromators, sample cells, detectors, single beam and double beam spectrophotometer, position and intensity of the bands, finger print region, applications of IR spectroscopy for structure analysis of organic, inorganic molecules & metal chelates. Attenuated total reflectance, Nondispersive IR, applications to quantitative analysis, Quantitative analysis of multi-component mixtures. Principles of Fourier transform infrared spectroscopy and its advantages.

**Raman Spectroscopy:**

Theory, Instrumentation, Characteristics of Raman lines, difference between IR and Raman, applications to organic and inorganic compounds and applications in quantitative analysis.

**UNIT-III NMR:**

**Advanced NMR Techniques :** Chemical Equivalence, magnetic equivalence, double resonance decoupling, Nuclear Over Hauser Effect (NOE),Qualitative Treatment & its use, factors influencing NMR spectra, FT NMR, double resonance, spin tickling, shift reagents, applications. Continuous wave NMR. Fourier transform NMR-Basic treatment, their differences and its advantages. Two dimensional NMR, Basic Principles, Types of 2D NMR, advantages of 2D NMR. Characteristics Nuclear properties of 1H, 13C, 19F and 31P NMR reference standards, ranges of chemical shifts, Homo & Hetero Nuclear coupling, Structural determination of simple Inorganic compounds containing these nuclei.

**UNIT-IV Mass spectrometry:**

Principles. Instrumentation, Methods of ionization, field desorption, spraying and ion evaporation, high speed particles and laser plasma desorption. Metastable ions – The origin of Metastable ions and usefulness of Metastable ions. Applications to inorganic systems: Isotopic abundance patterns for Cl, Ge, Br, Mo, Re, ReBr, ReBr2 applications in organ metallic carbonyls of Re2Cl2(Co)8, ReBr(Co)5.

**Quantitative mass spectrometry**: Introduction, principle, calibration and internal standards**,** general fragmentation, notes of organo transition metal alkyls, carbonyls, carbonyl halides, ionization potential, appearance potential.

**UNIT-V Photo Electron Spectroscopy and Flourimetry Principles, Types**

**X ray photoelectron spectroscopy:** Binding energies, chemical shift, structural factors on chemical shift, applications in qualitatitive analysis. X ray Fluorescence: principle, instrumentation, Qualitative &Quantitative applications. UV photoelectron spectroscopy of simple molecules like N2, O2, F2, Cl2, factors effecting UVPES.

**Fluorometry:** Fluorescence and chemical structure, basic principles of Instrumentation, Factors influencing. Intensity of Fluorescence, Fluorometric reagents, Quantitative analysis, advantages and limitations. Phosphorimetry – Theory, Instrumentation, chemiluminescence photoluminescence, applications.

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**Recommended books:**

1. Principles of Instrumental Analysis – 5th edition – Skoog. Holler. Nieman

2. Hobert.H.Wittard D.L Meritt and J.K.A.Dean Instrumentation –C.B.S.Publisheres

3. Inorganic electronic spectroscopy. A.B.P. Lever.

4. Chemical Analysis A.K.Srivatsava & Jain

5. Instrumental methodology, chemical analysis – Ewing

6. Infrared and Raman spectra of Inorganic and coordination compounds, Kazuo Nakamoto,

5th edition, John Wiley & Sons, 1955.

7. Mass Spectrometry for Chemists and Bio-Chemists,Robert A.W.Johnstone and

Malcolm.E.Rose,2nd Edition.

8. Hand book for Instrumental Techniques for Analytical Chemistry, Ed. Frank Settle

Prentice Hall, New Jersey, USA (1997).

9. Analytical chemistry, Gary D.Christian, Sixth edition, John Wiley and Sons. New York,

1994.

10. Analytical chemistry, Skoog & West, 6th edition.

11. Instrumental methods of Analysis\_Chatwal Anand.

12. Instrumental methods of Analysis-B.K.Sharma,Goel Publishing House,Meerut.

13. Mass Spectrometry Principles & Applications, Hoffman & Stroobant, 2nd Ed.(Wiley)

20003.

14. Analytical NMR Ed.Ld.Field and S.Stern hill, John Wiley and Sons. New York, 1989.

**SEMESTER-III**

**CORE ELECTIVE-III**

**ACT-304.1 HYPHENATED AND OTHER ANALYTICAL TECHNIQUES**

**UNIT-I: GC-MS –Introduction**

Instrumentation –GC-GC-MS interface-Mass spectrometer (MS), Instrument operation, processing GC-MS data –Ion chromatogram, Library Searching-Quantitative measurement – sample preparation, selected ion monitoring-Application of GC-MS for Trace constituents. Drugs analysis, environmental analysis and others.

**Gas Chromatography-Fourier Transform-Infrared (GC-FT-IR) :**

Principle, Instrumentation, Applications.

**UNIT-II: LC-MS –Introduction**

Instrumentation –liquid chromatography- Mass spectrometer,Interface- Instrumental detailsprocessing LC-MS data –Ion chromatograms,Library Searching-Quantitative measurements.sample preparation, Selected ion monitoring-Application of LC-MS for Drugs

analysis, Environmentalsamples and others.

**Inductively Coupled Plasma \_Mass Spectrometry (ICP-MS):**

Principle, Instrumentation, Applications.

**UNIT-III: Radio Chemical Methods :**

Radio active decay,Types of radiation, units and detection and measurements of radioactivity,activation analysis ,isotope dilution method,tracer techniques, Radiometric titrations.

**UNIT-IV: Thermal Mehods of Analysis:**

**a)Thermogravimetry**-Theory,Instrumentation, applications with special reference to CuSo4.5H2O,CaC2O4 .2H2O. Applications of TG study of oxalates and chromates.

**b) Differential thermal analysis-** Principle, Instrumentation, applications with special

reference to the Clays,minerals & Coals (fuels) .

**c) Differential Scanning Calorimetry-** Principle, Instrumentation, applications to inorganic

materials like chlorates and per chlorates, ammonium nitrate.Organic Compounds and Drugs.

**UNIT-V: Practical Aspects of Chemical Analysis:**

Analysis of real samples - Choice of analytical method; Literature survey; Analysis of standard samples; Preparing samples for analysis – preparing laboratory samples; moisture in samples; drying the analytical sample; decomposition and dissolution of sample and source of errors in decomposition and dissolution

**Recommended books:**

1. Analytical Chemistry- J.G.Dick

2. Electroanalytical techniques – Kaur

3. Principles of Instrumental analysis,Skoog Holler and Neimann West, 6th edition.

4. Vogels text book of Quantitative Inorganic Analysis. Ed. Bassett et al. longmann, ELBS

3rd edition.

5. W.Jeumings, Analytical gas chromatography, Academic Press, New York

6. Quntitative analysis VI Edition R.A.DayJr & AL.Underwood Prentice- Hall India.

7. Analytical chemistry, Gary D.Christian, 6th edition John Wiley and sons. Inc, New York,

1994.

8. polarographic methods in analytical chemistry M.G.Arrora

9. Instrumental methodology chemical analysis. Ewing.

10. Introduction to Inductively coupled plasma emission spectroscopy, G.I Moore, Elsevier

Science Publisher, New York, 1989.

11. Applications of ICP-MS, A.R.Date and A.L.Glay, London(Eds),Blakie,London

12. Instrumental techniques for Analytical chemistry, Ed. Frank Settle.

13. R.A Day A.C Underwood Qualitative analysis.

14. W.Wendtlandt, Thermal Analysis, John Wiley Sons, New York.

**SEMESTER-III**

**CORE ELECTIVE-IV**

**ACT-304.2 MEDICINAL INORGANIC CHEMISTRY**

**UNIT-I: Metal complexes as Drugs and Anticancer agents**

Introduction to Pt(II) chemistry – Thermodynamic and kinetic principles – Cis and Trans

influences – Thermodynamic and kinetic aspects.

Platinum complexes in cancer therapy: Discovery applications and structure-effect Relationships. Cis platin(cis Pt(NH3)2Cl2) mode of action. Drug resistance and DNA repairmechanism.

Physical effects of metal complex: DNA binding, unwinding, shortening and bending of thedouble helix. Biological consequences of platinum –DNA binding. Organic intercalators asdonor – acceptor pairs; Transition metal complexes as donor acceptor pairs. Non classical platinum antitumour agents.

**UNIT-II: Metal complexes in Clinical Chemistry**

Theory and mode of action of therapeutic chelating agents , Single ligand Chelation Therapy –Aminopolycarboxylic acids, Desferrioxamine, pencillamine, triethylenetetramine, Mixed ligand chelation therapy - Metallothionens in detoxification. Role of metal ions in the action of antibiotics: Bleomycin, adriamyacin and tetracyclines. Gold-Containing drugs used in therapy of Rheumatoid arthritis - A therapeutic agent for Menkes disease: Copper-histidine - Anti viral chemotherapy and metal peptide interaction.

**UNIT-III: Chemical probing of DNA complexes**

Chemical probing of DNA complexes: Introduction to foot printing. Chemical probing. Attack on DNA bases a) dimethylsulfate b) diethyl pyrocarbonate c) osmium tetraoxide d) ldehydese) ethyl nitrosourea (ENA) and other chemical probes like tris phenanthroline metal complexes.

**UNIT-IV: Photochemical probing of DNA complexes**

Photochemical probes: Psoralens, acridines, UV radiation Enzymatic probes Immobilization of enzymes: Methods and Applications. Platinum Metal Complexes as drugs and anticancer agents: Importance of binding and photoreactive metal complexes, ligand dissociation and photoactive metal complexes, ligand dissociation and photosubstitution, photophysics and photochemistry of Ru(II) polypyridyl complexes. Photophysics and photochemistry of Ru(ii) polypiridyl complexes. Photophysics in the absence of DNA and in the presence of DNA.

**UNIT-V: DNA binding and molecular pharmacology and Interaction of Metallo**

**Pharmaceuticals**

Introduction , concept of intercalating a) classical model b) developments of intercalation model c) quantitative analysis of intercalation.

Factors which relate intercalation and medicinal activity a) Binding constant b) kinetics

c)structural effects and activities d) intercalation and drug action Specific drugs which bind to DNA by intercalation : a) antipyranosomal drugs b) antimalarial drugs c) antitumor drugs. Nonspecific interaction in dye binding to DNA and influence of alcohols and amides. Ruthenium: Ru(III), amine complexes: Antitumor activity , structure activity relationship DNA binding and cleavage - DMSO complexes of Ru(II): DNA interactions of polyaromatic amines - Ru(IV) complexes oxidative DNA cleavage. Rhodium: Rhodium(II) acetate dimer. Anticancer activity metallocenes, Chemical correlation with antitumor activity, DNA binding and mechanistics possibility. Introduction, Structural and chemical properties of streptonigrin and its metal complexes - Evidence for formation of ternary complexes involving DNA and its components. Antitumor activity and mechanism - Metal induced free radical production by organic drugs in relation to their side effects.

**SUGGESTED BOOKS**

1. Bioinorganic Chemistry. Inorganic elements in the Chemistry of life, Wolfgang Kaim &

Brigette Schwederdki.

2. Handbook of Metal-Ligand interactions in Biological fluid Bioinorganic medicine, Vol –

2 : Edt. Guy Berthon.

3. Bioinorganic Chemistry, Rosette M. Roat Malone.

4. Photoreactions of Metal complexes with DNA, A. Krisch – De Mesmacker et al.

**SEMESTER-III**

**OPEN ELECTIVE-III**

**ACT-305.1: INDUSTRIAL & ENVIRONMENTAL ANALYSIS**

**UNIT-I Analysis of Air, water and solid wastes**

**a) Analysis of Air :**

Air pollutants,Chemical analysis of Air pollutants

**Primary air pollutants:** Carbon compounds(CO&CO2)

Sulphur compounds(SO2,SO3&H2S)

Nitro compounds (NO&NO2)

Hydrocarbons(Aliphatichydrocarbons,Polycyclic

Aromatic hydrocarbons)

**Secondary air pollutants:** Ozone, Peroxy Acetyl Nitrate(PAN)

**b) Analysis of water :** Analytical methods for analysis of following ions, Determination pH and TDS

**Anions :** carbonate, bicarbonate, fluorine, chlorine, Bromine and Iodine, sulphate, phosphate, nitrate, cyanide.

**Cations:** Na, K**,** Fe-II, Fe-III, Ca-II, Mg-II, Cr-III,Cr-VI

**c) Analysis of solid wastes, soils:** Sampling, determination of moisture, soil adsorption ratio. Analysis of environmental samples( soil and solid wastes for inorganic and organic pollutants) : volatile and semi volatile hydrocarbons, Poly Aromatic Hydrocarbons(PAHs) and chlorinated pesticides and inorganic cations and anions utilizing appropriate separartion methods followed by analysis using GC, GC-MS, HPLC

**UNIT-II Pharmaceutical Analysis**

Titrimetric analysis: Acid Base Titrations – Determination of percentage of Nicotinamide. Non Aqueous Titrations – Determination of Nicotine in Tobacco. Redox titrations – determination of percentage of chloramines. Precipitation titrations – determination of percentage of carbochol. Complexometric titrations – estimation of calcium and Mg in mineral tablets.

Separation of mixture of steroids by paper chromatography. Estimation of antibiotics like Norfloxacin,cipraflaxacin,cephaxinate formulation by U.V.Spectrometry. Simultaneous analysis of salicylamide & paracetamol by U.V.Spectrometry, determination of Aspirin, Caffeine, Phenacetin by NMR. Determination of zinc (the active components) in a soothing skin creams by AAS. Determination of vitamin B1 and B2, Quinine sulphate by Fluorimetry.

**UNIT-III Analysis of Rocks and Minerals**

a) General techniques of analysis applied to complex materials-Geological samples, Scope of geo-analysis-General methods of dissolution of complex materials- Various chemical methods for the effective separation of the constituents in the complex materials and their determination using sophisticated analytical techniques.

b) Analysis of Geological materials: Analysis of the Constituents – Moisture, loss of ignition, Total Iron, ferrous Iron, ferric Iron, alumina, Silica, Titania, Lime, Magnesia, Sulphur, phosphrous, manganese, alkalies, water of crystallization, U, Th, Rare earth elements, Nb, Ta, Zr, Hf, Mo, W,V, Cu, Co, Ni, Zn etc in Rocks and minerals.

**UNIT-IV Analysis of Finished Products and ores**

**Finished products:**

a) Analysis of steel for C, Si, S,P, Mn, Ni, Cr : Mg and analysis of blast furnace slag

b)Chemical Analysis of cement–silica, NH4OHgroup, ferric oxide, alumina, lime, magnesia, sulphide sulphur,K2O,Na2O,free CaO in cement and clinker,SO3 and loss on ignition

**Ores:**

a)Iron ore- Analysis of the Constituents – Moisture, loss of ignition, Total Iron, ferrous Iron, ferric Iron, alumina, Silica, Titania, Lime, Magnesia, Sulphur, phosphorous, manganese, alkalies, combined water, Carbon in blast furnace, flue dust and sinter.

b) Aluminium Ore (Bauxite)-Analysis of the Constituents – CaO, P2O5, SiO2, Fe2O3, MgO, MnO, Al2O3. Titania, vanadium, zirconium and alkalies.

**UNIT-V Analysis of Food, Additives and Pesticide residues**

**Analysis of Food:**

Determination of starch by saccharimetric method in flour. Analysis of dairy products, Analysis of caffeine in Tea and Coffee Analysis of chemical additives: Division of colour additives (Coal – tar dyes, vegetable colours and mineral colours) chromatographic identification of colours, quantitative estimation of added dyes in foods.

**Analysis of Food Additives:** Chemical preservatives and synthetic sweetening agents (organic – ether extractable and non-ether extractable) SO2, Sodium Benzoate, Sorbic acid, Benzoic acid. Antioxidants: Types of Antioxidants used in foods, analysis of butylated hydroxy tolune (BHT) by TLC & GC.

**Analysis of Pesticide residues:** Analysis of pesticide residues Endosulfan,endrin, BHC,2,4-

D,2,4,5-T by HPLC.

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**Recommended books:**

1. Environmental Pollution Analysis – S.M.Khopkar, Wiley Eastern Limited

2. Environmental Chemistry –B.K.Sharma – H.Kaur

3. Pharmaceutical chemistry, Instrumental techniques Vol-2, Edited by Leslie.G.Chatten.

4. Text Book of Pharmaceutical analysis – Kenneth. A.Connors

5. Handbook of analytical control of Iron and steel production,Harrison John, wiley 1979.

6. Standar mehods of Chemical Analysis,welcher

7. Technical Methods of Analysis,Griffin,Mc GRaw Hill

8. Environmetal Analysis – Chatwal

9. Aquatic Environmental Chemistry – Alan G.Howard

10. Environmental Analysis – C.S.Rao or S.M. khopkar(IIT Bombay)

11. A text book of Environmental Control & Pollution – S.S.Dara.

12. Biochemical methods – 2nd edition. S.Sadasivan, A.Manickam

13. Handbook of analysis and quality control for fruit and vegetables products- S.Ranganna.

14. Practical pharmaceutical chemistry, A.H.Beckett and J.B.Stenlake, III edition Vol 1 &

Vol.2.

15. Pharmaceutical analysis. P.Parimoo.

16. Environmental Chemistry – 4th edition – Anil Kumar.De Wiley Eastern Ltd.

17. Hand Book in Analysis and quality control for fruit and vegetable products-S.Ranganna.

**SEMESTER-III**

**OPEN ELECTIVE-III**

**ACT-305.2: LABORATORY ANALYSIS AND MANAGMENT**

**UNIT-I: Surface Analysis Methods**

Introduction, types of surface measurements.

**Photon Probe Tecnhniques**: X-Ray Photoelectron spectroscopy - Principle, Instrumentation,

applications.

**Electron Probe Techniques**: Scanning electron microscopy (SEM) – Principle,

Instrumentation, applications. Electron Probe X-ray analysis (EPXMA) - Principle,

Instrumentation, applications. Auger electron spectroscopy (AES) - Principle,

Instrumentation, applications.

**UNIT-II: Ion Probe Techniques**: Rutherford backscattering spectrometry (RBS) -Principle, Instrumentation, applications. Secondary ion mass spectrometry (SIMS) – Fundamental aspects of sputtering, Principle, Instrumentation (static & dynamic), applications

**Scanning probe microscopy Techniques**: Scanning Tunneling Microscopy – Principle,

Instrumentation, applications. Atomic Force Microscopy - Principle, Instrumentation,

applications.

**UNIT-III: Micromeritics, Dissolution and disintegration**

Particle size analysis- concepts of particle size, size distribution, mean size of particulate system, methods of particle size analysis (sieving, microscopic method, sedimentation methods, electrical sensing zone method, optical sensing zone and light diffraction method). Dissolution: Drug absorption, theories of drug dissolution – Diffusion layer model, Danckwert’s model & interfacial barrier model. Dissolution tests for tablets and capsules (basket apparatus, paddle apparatus, flow through cell apparatus). Disintegration tests for tablets, capsules and enteric coated tablets.

**UNIT-IV: Automation in Laboratory**

Introduction, classification of Analytical methods, Types of Instrumental methods, Instruments for analysis. Analog & Digital signals, Planning for laboratory automation. An overview of automatic instruments & instrumentation. Flow Injection Analysis, Discrete automatic systems.

**Good laboratory practices:** Instrumental standardization, optimization of procedures.

**UNIT-V: LIMS and Computer aided Analysis**

**Laboratory Information Management System**: Laboratories as information producers, properties of good information, Laboratory information management system, conclusions. **Computer aided analysis:** Computer-instrument interaction, computer organization- Hardware - Basic Digital circuit components, Microprocessors and Microcomputers, Computer Software - Software control of the computer-instrument interfaces. Automated laboratory – Automated instruments (AAS), Applications of computers, Computer Networks.

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**Suggested Books**

1. Structural methods in Inorganic Chemistry - E.A.V. Ebsworth, et al., ELBS Publications, 1988.
2. Physical Methods in Chemistry - R.S. Drago, W.B. Saunders Co, 1977.
3. Instrumental Methods & Chemical Analysis – Galen Ewing, 5th ed., McGraw-Hill Publishing Company Ltd., 1985.
4. Analytical Chemistry - Gary D. Christian, 6th ed. John Wiley and sons. Inc, New York, 1994.
5. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998
6. Principles and practice of Analytical Chemistry, F.W.Fifield & D Kealey, 5th Ed. Blackwell Science, 2000.
7. Quantitative Chemical Analysis, Daniel C. Harris, 6th Ed. WH Freeman & Co. NewYork,2003.
8. Instrumental Methods of Analysis - Willard, Merit, Dean, 6th ed., CBS Publishers & distributors, 1986.
9. Handbook of Quality Assurance for the analytical chemistry laboratory, James P. Dux, Van Nostrand Reinhold, New York, 1986.
10. Quality in Totality – Parag Diwan, Deep & Deep Publications, 1st ed., 2000.

**SEMESTER-III**

**LABORATORY-V**

**ACP-306 WET ANALYSIS LAB**

**Titrimetry**

1. Determination of Ca2+, Mg2+, CO3 2- & HCO3 - in soil sample.
2. Determination of Fe & Ca in Cement
3. Determination of Saponification value and Iodine value of an oil sample
4. Determination of Ampicillin and amoxicillin
5. Determination of Ampicillin and Di cloxacillin in combined form
6. Analysis of Albendazole drug by Non Aqueous Titrations
7. Analysis of Atenolol drug by Non Aqueous Titrations
8. Analysis of Glipizide drug by Non Aqueous Titrations
9. Analysis of Domperidone drug by Non Aqueous Titrations
10. Analysis of chloro pheneramine maleate drug by Non Aqueous Titrations

**Solvent Extraction**

1. Determination of Pb using Dithiazone

**Flame Photometry**

1. Determination of i) Na, ii) K, iii) Ca, iv)Li

**SEMESTER-III**

**LABORATORY-VI**

**ACP-307 ANALYTICAL INSTRUMENTION LAB**

**Spectroscopic and chromatographic methods of analysis of drugs and pharmaceuticals**

***I. COLORIMETRY***

1. Determination of Paracetamol
2. Determination of Ampicilin
3. Estimation of Ascorbic acid
4. Determination of ciprofloxacin

***II. SPECTROPHOTOMETRY***

1. Determination of pKa of an organic Indicator (Methyl Orange)
2. Simultaneous determination of Cr and Mn in an admixture
3. Spectrophotometric Titration of Fe(II) with o-Phenanthroline
4. Determination of composition of Complex by Job’s Method and Mole ratio Method ofCu(II)-EDTA complex

***III. CHROMATOGRAPHY***

1. Separation of amino acids in a mixture by TLC using Ninhydrin
2. HPLC study of Six available drugs.

**Recommended books:**

1. Chemistry Experiments for Instrumental Methods, Donald T Sawyer William

R.Hememan etal John Wiley & Sons 1984.

2. Analytical Chemistry by Gary D.Christian 6th Edition John Wiley&Sons Inc New York

1994.

3. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel 3rdEdition Elbs Publication

1969.

4. Vogel’s Text Book Of Quantitative Inorganic Analysis Jeffery etal 4th edition Elbs

Publications 1988.

5. Vogel’s Text Book of Quantitative Chemical Analysis, 6th edition. Pearson Education Ltd

2002.

6. Analytical Chemistry Thoery and Practice by R.M. Verma 3rd Edn.CBS Publishers &

Distrbutors1994.

7. Comprehensive Experimental Chemistry by V.K. Ahluwalia etal New Age Publications

1997.

8. Laboratory hand Book of Instrumental Drug Analysis.by B.G. Nagavi 2nd edn. 1996

9. Practical Pharmaceutical Chemistry, A.H. Beckett and J.B. Stenlake 4thedn. CBS

publishers, 2001

10. Separation methods, MN Sastri, 2nd edn, Himalaya Publishing House1996

11. Hand book of analysis and quality control for fruit and vegetable products. S. Ranganna,

2nd edn, Tata MCGraw-Hill Publishing Company, 2002.

12. Gas Chromatography, Rajbir Singh, 1st edn, Mittal Publications, 2002