COURSES OF STUDIES FOR THE M.Sc. EXAMINATION IN ANALYTICAL CHEMISTRY

SEMESTER-I and II
SEMESTER-III and IV

The two year course in analytical chemistry shall comprise four semesters. There shallbe sixteen theory papers, three practical papers and one dissertation. Each theory papershall carry 10+40 marks. Each practical paper shall carry 20+80 marks. The dissertation carries 100 marks. The dissertation is expected to be carried out under the supervision of a faculty member of the Department.

Each theory paper shall carry four units. Questions will be set unit wise.

SEMESTER -I
PAPER-I (CA-1.1.1)
INORGANIC CHEMISTRY

***Learning Objectives*:** This paper aims to introduce the students to stereochemistry and bonding in main group compounds, symmetry, group theory and chemistry of main group elements.
***Learning Outcomes*:** This paper will ensure that the students learn to predict structures of main group compounds, do symmetry operations & predict point groups. Students will learn to applythe great orthogonality theorem and use of character tables. Students will gain a sound knowledge about some industrially important compounds of main group like Boranes, Carboranes, Silicones, Silicates, Boron nitride, Borazines, Phosphazenes etc. and also about Hydrides, Oxides and Oxoacids of pnictogens (N, P), chalcogens (S, Se & Te) and halogens, Xenon compounds, Pseudo halogens and Interhalogen compounds

Marks-10+40

UNIT-I Stereochemistry and Bonding in main group compounds

VSEPR, Walsh diagram (tri molecules), d_z-P_π bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.

UNIT-II Symmetry and Group Theory

Symmetry elements and Symmetry operation, Groups and Subgroups, Symmetry point group. Schonflies symbols, Matrix representations of groups. Character of a representation. The Great Orthogonality theorem (without proof) and its importance. Character tables and their uses. Derivation of character table for C_{2v}, C_{3v}.

UNIT-III Chemistry of Main Group elements A

General characteristics, Allotropes, Structure and Reactions of simple and industrially important compounds: Boranes, Carboranes, Silicones, Silicates, Boron nitride, Borazines and Phosphazenes.

UNIT-IV Chemistry of Main Group elements B

General characteristics, Structure and Reactions of simple and industrially important compounds: Hydrides, Oxides and Oxoacids of pnictogens (N, P), chalcogens (S, Se & Te) and halogens, Xenon compounds, Pseudo halogens and Interhalogen compounds.

Books and References:

1. *Chemical Application of Group Theory*: F. A. Cotton, John Wiley.
2. *Symmetry in Chemistry*: Orchin and Jaffe.
3. *Group theory*: K. V. Raman, Tata McGraw Hill.
4. *Advanced Inorganic Chemistry*: F. A. Cotton and G. Wilkinson, John Wiley.
5. *Inorganic Chemistry*: J.E. Huheey, E. A. Keiter, R. L. Keiter, Pearson Education.
6. *Chemistry of the Elements*: N. N. B. Greenwood and A. Earnshow, Pergamon.
7. *Comprehensive Coordination Chemistry* eds.,- G. Wilkinson, R. D. Gillars and J. A. McCleverty, Pergamon.

PAPER-II (CA-1.1.2)
ORGANIC CHEMISTRY

***Learning Objectives*:** The main objective of this paper is to introduce the students to the reaction dynamics i.e., the study of reaction mechanism.

***Learning Outcomes*:** The outcome of the course is to ensure that the students develop a critical understanding of reaction mechanism, kinetics and thermodynamics of organic reaction.

Marks-10+40

UNIT-I Reaction Mechanism: Structure and Reactivity: (a) Types of mechanism, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin - Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Hard and soft acids and bases. **(b)** Generation, structure, stability and reactivity of carbocations, carbanions, free radicals. Carbenes and nitrenes. Effect of structure on reactivity: resonance and field effect, steric effect, quantitative treatment. The Hammett equation and linear free energy relationships, substitutent and reaction constants. Taft equation.

UNIT-II (a) Aliphatic Nucleophilic substitution: The S_N2, S_N1, mixed S_N1 and S_N2 and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by σ and π bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations.

The S_N1 mechanism: Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

(b) Selective organic name reactions: Favorski reaction, stock enamine reaction, Mannich reaction, Sharpless asymmetric epoxidation, ene reaction, barton reaction, Baeyer-Villiger reaction, Chichibabin reaction, Claisen condensation, Claisen reduction, Curtius Rearrangement, Demjanov rearrangement, Dieckmann condensation, Favorskii rearrangement, Horner-Wadsworth-Emmons olefination, Wittig olefination, Wolff- kishner reduction, Mitsunobu reaction, Fries rearrangement, Peterson olefination, Macmurry Coupling

UNIT-III (a) Aromatic Nucleophilic Substitution: The S_NAr, S_N^i benzyne and SR_N1 mechanisms. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.

(b) Aromatic Electrophilic Substitution: The areniun ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, Ipso attack, orientation in other

ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeier reaction, Gattermann- Koch reaction.

UNIT–IV (a) Free Radical Reactions: Types of free radical reactions: Free radical substitution, mechanism, mechanism at an aromatic substrate, neighbouring groupassistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity inthe attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction, free radical rearrangement, Hunsdiecker reaction.

(b) Elimination Reactions: The E2, EI and E1cB mechanisms. Orientationof the double bond. Reactivity: Effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

Books and References:

1. *Organic chemistry*: J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford UniversityPress.
2. *Advanced Organic Chemistry Reactions, Mechanism and Structure*: Jerry March. JohnWiley and Sons.
3. *Advanced Organic Chemistry*: F. A. Carey and R. J. Sundberg. Plenum.
4. *A Guide Book to Mechanism in Organic Chemistry*: Peter Sykes, Longman/Pearson Education.
5. *Structure and Mechanism in Organic Chemistry*: C. K. Ingold. Cornell University Press.
6. *Organic Chemistry*: R. T. Morrison and R. N. Boyd. Prentice Hall/Pearson Education.
7. *Modern Synthetic Reactions*: Second Edition, H. O. House, Benjamin, Menlo Park, 1972.
8. *Principles of Organic Synthesis*: R. O. C. Norman and J. M. Coxon. Blackie Academic andProfessional / CBS Publishers.
9. *A logical Approach to Modern Organic Chemistry*: Dr. Jagdamba Singh and Dr. S. Anandvardhan. Pragati Prakasan.
10. *Reaction Mechanism in Organic Chemistry*: S. Mukherji and S. P. Singh, Macmillan.
11. *Advanced Organic Chemistry*: Reactions and Mechanism: B. Miller and R. Prasad. Pearson-Education.
12. *Stereochemistry of Organic Compounds*: D. Nasipuri, New Age International.
13. *Stereochemistry of Organic Compounds*: P. S. Kalsi, New Age International.
14. *Stereochemistry of Organic Compounds*: E. L. Eliel and S. H. Wilen. John Wiley.
15. *Stereochemistry, Conformation and Mechanism*: P. S. Kalsi, New Age International.

PAPER-III (CA-1.1.3)
PHYSICAL CHEMISTRY

***Learning Objectives*:** This course is intended to introduce students to the quantum chemistry, approximation methods and structure and bonding.

***Learning Outcomes*:** After the completion of the course, the students will have a comprehensive understanding of the development of scientific ideas about structure and bonding

Marks-10+40

UNIT-I Quantum Chemistry: The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz. particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

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

UNIT-III Electronic Structure of Atoms: Multielectron atom. Electronic configuration. Russell-Saunders terms and coupling schemes, magnetic effects: spin-orbit coupling and Zeeman splitting.

UNIT-IV Molecular Orbital Theory: H_2^+ and H_2 molecules: Valance bond theory (VBT) and molecular orbital theory (MOT) approaches. Homonuclear and Heteronucleardiatoms. Huckel theory of conjugated systems, bond order and charge density calculation. Applications toethylene, butadiene, cyclopropenyl radical, and cyclobutadiene.

Books and References:

1. *Atkin's Physical Chemistry*: P. W. Atkins, J. D. Paula, Oxford University Press
2. *Introductory to Quantum Chemistry*: 4th Ed., A. K. Chandra, TataMc Graw Hill.
3. *Quantum Chemis*try: Ira N. Levine, Prentice Hall.
4. D. A. McQuarrie and J. D. Simon, *Molecular Thermodynamics*, University Science Books,California 2004.
5. R. S. Berry, S. A. Rice and J. Ross, *Physical Chem*istry, 2nd Edition, Oxford UniversityPress, Oxford 2007.
6. D. A. McQuarrie, *Statistical Mechanics*, University Science Books, California (2005).
7. B. Widom, *Statistical Mechanics - A Concise Introduction for Chemists*, Cambridge University Press 2002.
8. D. Chandler, *Introduction to Modern Statistical Mechanics*, Oxford University Press 1987.
9. *Physical Chemistry* Vol-II: .K. L. Kapoor, Mcmillan Publication.
10. *Statistical Thermodynamics*: M. C. Gupta, New Age Pvt Publication.

PAPER-IV (CA-1.1.4)
PHYSICAL CHEMISTRY

***Learning Objectives*:** This course is intended to introduce students to the various facets of thermodynamics and chemical dynamics, which deals with the laws of thermodynamics, the concept of chemical potential and partial molar properties, Phase, concepts of thermodynamicprobability and chemical dynamics.

***Learning Outcomes*:** The outcome of the course is to ensure that the students develop a critical understanding of thermodynamic systems, statistical thermodynamics and chemical dynamics

Marks-10+40

UNIT-I Classical Thermodynamics: Brief resume of concepts of laws of thermodynamics, entropy and free energy. The concept of chemical potential and partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significance. Determination of these quantities. Concept of fugacity and determination of fugacity. Activity, activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients, ionic strength.

UNIT-I Classical Thermodynamics: Brief resume of concepts of laws of thermodynamics, entropy and free energy. The concept of chemical potential and partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significance. Determination of these quantities. Concept of fugacity and determination of fugacity. Activity, activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients, ionic strength.

UNIT-II Phase Diagram: Phase behavior of one and two component systems (solid-solid, solid-liquid, solid-vapor, liquid-liquid, liquid-vapor equilibrium). Ehrenfest classification of phase transitions.

UNIT–III Statistical Thermodynamics: Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging, Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers)

Partition functions-translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition function. Fermi-Dirac statistics, distribution law and application to metal. Bose-Einstein statistics - distributionlaw and application to helium.

UNIT–IV Chemical Dynamics: Potential energy surfaces. Collision theory of reaction rates, Conventional transition state theory (CTST); CTST as applied to ionic reactions, kinetic salt effects. steady state kinetics. Kinetic and thermodynamic control of reactions.

Treatment of unimolecular reactions. dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice Ramps Berger - Kassel Marcus (RRKM) theories of unimolecular reactions).

Dynamics chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen -bromine and hydrogen - chlorine reactions) and oscillatory reactions (Belousov- Zhabotinski reaction), homogeneous catalysis, kinetics of enzyme reactions. General features of fast reactions, study of fast reactions by flow methods, relaxation methods, Flash photolysis. Dynamics of barrier less chemical reactions in solution.

PAPER-V (CA-1.1.5)
INORGANIC CHEMISTRY PRACTICAL

***Learning Objectives*:** This course aims to explain the students how to classify acid and basic radicals into different groups and their chemical analysis. Synthesis of some selected inorganic complexes is also covered under this course.

***Learning Outcomes*:** After completion of this course students should be able to analyze mixture of inorganic salts and insoluble inorganic samples. Able to identify acid and basic radicals in a sample of unknown mixtures. They should be able to handle air and moisture sensitive chemicals for the synthesis and study of complexes and inorganic reactions.

Marks-20+80

1. Qualitative analysis of mixtures containing not more than eight radicals [less common metal ions Mo, W, Ti, V, Zr, U (two metal ions in cationic / anionic forms), insoluble-oxides, sulphates and halides may be included].
2. Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods.
3. Synthesis of bulky Schiff base (Ketimine/ diketimine/ phenolate) transition metal complexes.
4. Preparation of some selected inorganic compounds and their study. Handling of air and moisture sensitive compounds.
   a) $Mn(acac)_3$
   b) $K_3[Fe(C_2O_4)_3$.
   c) $[Ni\ (NH_3)_6]\ Cl_2$
   d) $[\ Ni(dimg)_2$.
   e) $[Cu\ (NH_3)_4].\ SO_4.H_2O$
   f) Cis - and Trans $[Co\ (en)_2]Cl_2$.
5. Wilkinson's catalyst, $(PPh_3)_3RhCl$:
   a) Synthesis of Wilkinson's catalyst
   b) Reaction of Wilkinson's catalyst with Cyclohexene

c) Reaction of Wilkinson’s catalyst with Hydrogen.

Books and References:

1. *Inorganic Experiments*: J. Derck Woollins, VCH.
2. *Microscale Inorganic-chemistry*; Z.Szafran, RM. Pike and M.M.Singh. Wiley.
3. *Practical Inorganic Chemistry*: G.Marr and B.W. Rockett, van,Nostrand.
4. *Vogel'-s Qualitative Inorganic Analysis (revised)* : G. Svehla, Longman.

SEMESTER -II
PAPER – VI (CA-1.2.6)
INORGANIC CHEMISTRY

***Learning Objectives*:** The objective of this course is to introduce students to chemistry of transition and inner transition elements and chemistry of lanthanides and actinides. This course deals with the electronic spectra of transition metal complexes, the nature of metal- ligand bonding and coordination chemistry of metal ions.

***Learning Outcomes*:** This course shall ensure that students get a thorough knowledge on CFT and MOT of transition metal complexes. Students will have a firm understanding of Orgel and Jahn-Teller diagrams, structure of mixed metal oxides and chemistry of inner transition elements.

Marks-10+40

UNIT-I: Electronic Spectra of Transition Metal Complexes: Spectroscopic ground states, Orgel diagrams for d^1-d^9 states in Oh and Td symmetry, Tanabe-Sugano diagrams for d^2 configuration in Oh and Td symmetry. Calculations of Dq, B and β parameters.

UNIT-II Metal-Ligand Bonding: Crystal-Field Theories: Limitation of Crystal Field Theory, Molecular orbital theory for Octahedral, Tetrahedral and Square Planar Complexes, σ and π bonding in Molecular Orbital Theory. Application of MOT to Correlation diagrams.

UNIT-III: Chemistry of Transition Transition Elements: Coordination chemistry of Transition Metal ions, Stabilization of Unusual oxidation states, Stereochemistry of coordination compounds, splitting of d-orbitals in Low symmetry environment, Jahn-Teller effect, Interpretation of Electronic Spectra including Charge Transfer Spectra, Spectrochemical series, Nephelauxetic series, Fluxional molecules, Iso and Hetero Poly acids. Structures of Mixed Metal Oxides: Spinel & Inverse Spinel, lleminite and Perovskite structure, Coloured Minerals and Gem quality crystals.

UNIT-IV: Chemistry of Inner Transition Elements: Chemistry of Lanthanides and Actinides: Lanthanide Contraction, Separation of Lanthanide elements, Oxidation state, Spectral and Magnetic Properties, Stereochemistry, Use of Lanthanide Compounds as Shift reagents, Actinide contraction, Oxidation states, Comparisons between Lanthanides and Actinides.

Books and References:

1. *Advanced Inorganic Chemistry: A Comprehensive Text*: F. A. Cotton and G. Wilkinson,John Wiley.
2. *Inorganic Chemistry: Principles of Structure and Reactivity*: J. E. Huheey, E. A. Keiter and R. L. Keiter, Addition Wisley Publishing Company.
3. *Comprehensive Coordination Chemistry* eds.: G. Wilkinson, R. D. Gillars and J. A. McCleverty, Pergamon.

4. *Inorganic chemistry*: Gary L. Miessler, Donald A. Tarr, Pearson

PAPER -VII (CA-1.2.7)
ORGANIC CHEMISTRY

***Learning Objectives*:** This course deals with brief understanding of nature of bonding in organic compounds and stereochemical aspects. Different types of addition reaction to carbon-carbon double bonds and carbon-hetero multiple bonds, different classes of pericyclic reactions are introduced in this course. Students are also introduced to target oriented synthesis through retrosynthetic approaches.

***Learning Outcomes*:** This course will ensure that the students shall understand the bonding of complex polyenes, aromaticity and will gain a sound knowledge about stereochemistry of organic compounds. They should also get a clear idea of reactionmechanism of carbonyl compounds and get an insight into different theories and application of pericyclic reactions. After completing this course, they should be able to design logical synthetic steps toward synthesis of a target molecule.

Marks-10+40

UNIT-I (a) Nature of Bonding in Organic Molecules: Delocalized chemical bonding: conjugation, cross conjugation, resonance, hyperconjugation, tautomerism. Aromaticity in benzenoid and nonbenzenoid compounds, alternant and non-alternant hydrocarbons. Huckel's rule, energy level of π-molecular orbitals, annulenes, antiaromaticity, ψ-aromaticity, homoaromaticity, Fullerene (C_{60})

(b) Stereochemistry: Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding.

Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotropic and diastereotropic atoms, groups and faces, stereospecifjc and, steroselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helicalshape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

UNIT–II (a) Addition to Carbon-Carbon Multiple Bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, selectivity, orientation and reactivity, Electrophilic cyclization, Baldwin's rule. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration, Michael reaction. Sharpless asymmetric epoxidation.

(b) Addition to Carbon-Hetero Multiple Bonds: Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving

enolates, Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

UNIT-III Pericyclic Reactions: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1, 3, 5 – hexatriene and allyl system. Classification of pericyclic reactions. WoodWard –Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions, conrotator and disrotatory motions; 4n, 4n+2 and allyl systems. Cycloadditions, antarafacial and suprafacial additions; 4n and 4n+2 systems, 2+2 addition of ketenes. 1, 3 - dipolar cycloadditon and cheletropic reactions. Sigmatropic rearrangements - suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3, 3 - and 5, 5 –sigmatropic rearrangements: Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

UNIT-IV (a) Disconnection approach: An introduction to synthons and synthetic equivalents, disconnection approach, functional group interconversions, the importance of the order of events in organic synthesis, one group C-X and two groups C-Xdisconnections, chemoselectivity, reversal of polarity (umpolung reaction), cyclisation reactions, amine synthesis.

(b) Protecting groups: Principle of protection of alcohol, amine, carbonyl, carboxyl groups and Umpolung Reaction

(c) One group C-C disconnection: Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

(d) Two group C – C disconnection: Diels-Alder reaction, 1,3 – difunctionalized compounds, alpha, beta- unsaturated carbonyl compounds, control in carbonyl condensations, 1,5 – difunctionalized compounds, Michael addition and Robinson annelation.

(e) Chemistry of Natural Products: Application of Disconnection approach in the construction of biomolecules like Synthesis of Camphor, Longifoline & Juvabione.

Books and References:

1. *Organic chemistry*: J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford UniversityPress.
2. *Advanced Organic Chemistry Reactions, Mechanism and Structure*: Jerry March. John Wiley and Sons.
3. *Advanced Organic Chemistry*: FA Carey and RJ. Sundberg. Plenum.
4. *Photo Chemistry and Pericyclic Reactians*: Jagdamba Singh and Jaya Singh, New AgeInternatianal.

PAPER VIII (CA-1.2.8)
PHYSICAL CHEMISTRY

***Learning Objectives*:** This course introduces students to surface chemistry including adsorption and surface tension. An outline on micelles is provided here. The course also deals with electrochemistry and ion-ion, ion-solvent interactions and electrodics. Lastly, an introduction to error analysis is given

Learning Outcomes: After successful completion of this course students should be able to understand statistical methods in chemical analysis. They should have a proper understanding of micellar systems, CMC, solubilization and reverse micelles. The students are also expected to gain insights into adsorption isotherms and catalytic activity in surfaces.

Marks-10+40

UNIT-I Surface Chemistry: (a) Adsorption: Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation). Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electrokinetic phenomenon), catalytic activity at surfaces.

(b) Micelles: Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants counter ion binding to micelles, thermodynamics of micellization, phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

UNIT-II Electrochemistry: (a) Ion-Solvent interactions: Nonstructural treatment of ion- solvent interaction, quantitative measure of ion solvent interactions. The Born model, Electrostatic potential at the surface of a charged sphere. The electrostatics of charging and discharging spheres. The Born expression for the free energy of ion-solvent interactions, the interaction of a single ionic species with the solvents. Experimental evaluation of the heat of interaction of a salt and solvent, limitation of Born theory.

Structural treatment of the ion-solvent interactions, structure of water near an ion, Ion-dipole model of ion solvent interaction, ion-dipole approach to the heat of salvation, limitation of ion-dipole theory of salvation, water molecule as electrical quadrupole, ion-quadrupole model of ion-solvent interaction, Ion-induced dipole interactions in theprimary salvation sheath, Limitation of ion-quadrupole theory of salvation.

(b) Ion-Ion interactions: Debye-Huckel-Onsager treatment and its extension. Debye-Huckel- Jerrum model.

UNIT-III Electrodics: Thermodynamics of electrified interface equations. Derivation of electrocapillarity; Lippmann equations (surface excess), methods of determination,Structure of electrified interfaces. Overpotentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot, interfaces-theory of double layer at semiconductor- electrolyte solution interfaces. Effect of light at semiconductor solution interface. Electrocatalysis-influence of various parameters. Diffusion layer. The limiting current density and its practical application. Corrosion, Battery and Fuel cell.

UNIT-IV Error Analysis: Statistical methods in chemical analysis: Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of twostandard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method for linear plots).

Books and References:

1. *Physical Chemistry*: P. W. Atkins, J. D. Paula, Oxford III University Press.
2. *Introduction to Quantum Chemistry:* A. K. Chandra, Tata Mc Graw Hill.
3. *Quantum-Chemistry:* Ira N. Levine, Prentice Hall.
4. *Coulson's Valence*: R Mc Weeny, ELBS.
5. *Chemical Kinetics*: K. J. Laidler, McGraw-Hill.
6. *Kinetics and Mechanism of Chemical Transformation*: J. Rajaraman and J. Kuriacose, McMillan.
7. *Micelles, Theoretical and Applied Aspects*, V. Moroi, Plenum.
8. *Modem Electrochemistry*: Vol.-I and Vol. II, J. O. M. Bockris and A. K. N. Reddy, Plenum.
9. *An Introduction to electrochemistry*: S. Glasstone, Affiliated East-West Press Pvt. Ltd.
10. *Principles of instrumental analysis*: D. A. Skoog, 5th edn, Sauns College Publishing Philadelphia (London).
11. *Basic concepts of analytical chem*istry: S. M. Khopkar, Wiley Eastern

PAPER-IX (CA-1.2.9)
ORGANIC SPECTROSCOPY

Learning Objectives: This course is basically focused on structure determination of organic molecules using spectroscopic method such as ultra violet (UV), infrared (IR), nuclear magnetic resonance (NMR) spectroscopy of ^{1}H and ^{13}C and mass spectroscopy (MS). This course introduces the basic principles of electronic transition, selection rule, molecular vibrations and absorption of electromagnetic radiation. Also nuclear spin and interaction of radiation with nucleus and fundamental principle of NMR spectroscopy is discussed. 2D NMR is also discussed such as COSY, NOESY, DEPT, APT for structure determination. Basic principles, instrumentation and application of MS are also covered.

Learning Outcomes: After successful completion of this course students should be able to elucidate the structure and molecular mass of small organic molecules using UV, IR, NMR, MS. Calculate the absorption maxima of conjugated molecules using Woodward rule. To gain firmidea of functional groups present in a molecule from IR spectroscopic idea.

Marks- 10 + 40

UNIT-I (a) Ultraviolet and Visible Spectroscopy: Various electronic transitions, Beer

Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds, steric effect in biphenyls.

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

UNIT II: Nuclear Magnetic Resonance Spectroscopy (NMR): General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic, and aromatic compounds) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides, and mercapto), chemical exchange, effect of deuterium, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling, stereochemistry, hindered rotation, karplus curve- variation of coupling constant with dihedral angle, simplification of complex spectra, nuclear magnetic double resonance, NMR shift reagents, solvent effects, Fourier transform technique, nuclear overhauser (NOE). Resonance of other materials.

UNIT III Carbon-13 NMR spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two-dimension NMR spectroscopy – COSY, NOESY, DEPT, APT and INADEQUATE techniques.

UNIT IV Mass spectrometry: Introduction, ion production – EI, CI and FAB factors affecting fragmentation, ion-analysis, ion analysis, ion abundance, mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement, nitrogen rule, high resolution mass spectrometry, examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Books and References

1. Silverstein, R. M.; Webster, F. X. *Spectrometric identification of organic compounds*; 6th /ed.; Wiley: New York, 1998.
2. Lambert, J. B; Shurvell, H. F, *Organic structural spectroscopy*, Prentice Hall, 1998.
3. Kemp, W. *Organic spectroscopy*; 3rd ed.; Macmillan Education: Houndmills, Basingstoke,Hampshire, 1991.
4. Levitt, Malcolm H.; *Spin Dynamics-Basics of Nuclear Magnetic Resonance*, Second edition; John Willey & Sons Ltd.

PAPER-X (CA-1.2.10)
ORGANIC CHEMISTRY PRACTICAL

***Learning Objectives*:** This course is designed to introduce students to basic separation techniques and purification of organic samples using TLC and column chromatography. Synthesis of certain derivatives of amino group and hydroxyl groups and some aromatic nitro compounds are also included in this course.

***Learning Outcomes*:** This course ensures that the students shall be able to purify and separate a mixture of organic samples. They should be able to perform synthesis of derivatives of simple functional groups and purify them.

Marks. – 20+ 80

1. Separation, purification and identification of compounds of binary mixtures (solid- solid, solid-liquid, liquid-liquid) using TLC and column chromatography, Chemical tests.

2. Quantitative Analysis:

(a) Determination of amino group by acetylation method.
(b) Determination of hydroxyl group by acetylation method.
(c) Estimation of Keto group.
(d) Determination of iodine value and saponification value of an oil sample.

3. Organic Synthesis:

(a) Preparation of adipic acid, p-chlorotoluene, p-nitroaniline, p-bromoaniline, triphenylmethanol.
(b) Preparation of PDC (Pyridinium dichromate) & PCC (Pyridinium chlorochromate) reagents and its application on benzyl alcohol.
(c) Grignard reagent preparation and reactions on aldehyde.

Books and References:

1. *The Systematic Identification of Organic Compounds*: R.L. Shriner, C. K. F. Harmann, T.C.Morrill, D.Y. Curtin, R.C. Fusion, John Wiley and Sons.
2. *Organic Analytical Chemistry (Theory and Practice)*: Jagmohan, Narosa Publishing House.
3. *A Text Book of Practical Organic Chemistry*: Arthur I.Vogel, .E.L.B.S. and Longman.
4. *Experiments and Techniques in Organic Chemistry*: D. Pasto, C. Johnson.
5. *Laboratory Mannual of Organic Chemistry*: B.B. Dey and M.V.Siaram (Revised)-
   :T.R.Govindachari, Allied Publishers.
6. *Systematic Qualitative Organic Analysis*: H. Middleton, Orient Longman.
7. *A Hand Book of Organic Analysis (Qualitative and Quantitative)*: H.T. Clarke, Revised, B.Haynes, Arnold Publishers.

SEMESTER – III
PAPER-XI (CA-2.3.11)
ANALYSIS OF MATERIALS

Learning Objectives: This paper aims to introduce the students to different materials such as cement, paint and pigments and their compositions. This course also deals with classification, and components of water and soil and their chemical analysis.

Learning Outcomes: This paper will ensure that the students learn to analyze and classify different materials like cement, paint and pigments and also natural elements like water and soil. After completing this course they will be able to do the sampling and chemical analysis of these materials for ensuring the quality and standard of these materials. They can also determine the DO, COD, BOD of water samples which are very essential for quality determination of water.

Marks: 10+40

UNIT I: Analysis of cement: Introduction, types of cement and their utilization, Chemical Analysis of cement-silica, NH_4OH group, ferric oxide, alumina, lime, magnesia, Sulphide Sulphur , K_2O, Na_2O, free CaO in Cement and Clinker,SO_3 and loss on ignition.

UNIT II: Sources of water, classification of water for different uses, types of water pollutants and their effects, Analytical methods for the determination of ions in water: CO_3^{2-} , HCO_3^- , F^- , Cl^- , SO_4^{2-} , PO_4^{3-} , NO_3^- , Analytical methods for the determination of cations in water: Fe^{2+}, Fe^{3+}, Ca^{2+}, Mg^{2+}, Cr^{3+} , As^{5+}, Pb^{2+}, Hg^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+}, Co^{2+} Determination of Dissolved oxygen (D.O), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), standards for drinking water.

UNIT III: Analysis of Soil: Sampling, Carbonate, Organic carbon, and organic matter, Total nitrogen, ammonia and nitrates, Total determination of major soil constituents by fusion analysis, silica and total combined oxides of iron, aluminium, and titanium, Determination Ca, Mg, Na, K, phosphate, boron, Co, Cu, Zn, Exchangeable cations Cation exchange capacity, chemical analysis as a measure of soil fertility.

UNIT IV: Analysis of Paints and Pigment: Introduction, test on the total coating, water content, separation of pigment binder, and thinner of solvent type coating, separation of pigment binder, and

thinner of latex paints, Identification of the binder, Identification of polymer resins and oils, Identification of plasticizer, Analysis of the vehicle, Identification and Analysis of pigments, Identification of inorganic pigments.

Books and References:

1. Soil Pollution. S. G Mishra and Dinesh Mani. APH Publishing. Corporation. (2009)
2. Environmental Pollution Analysis. S. M. Khophor. John Wiely
3. Abranart: Dyes and Their Intermediates (Pergaman)
4. K. Venkatraman: The chemistry of Synthetic Dyes Vol. 1-7 (A.P.)

PAPER-XII (CA-2.3.12)
CHROMATOGRAPHY

***Learning Objectives*:** This paper aims to introduce the students to different chromatographic separation technique which are used very frequently for analysis, separation and purification of organic and inorganic samples. From historical development to modern advance instrumental methods such as HPLC and GC are covered in this paper.

***Learning Outcomes*:** This paper will ensure that the students shall be familiar to the most important branch of modern analytical technique for qualitative as well as quantitative estimation of samples. After this course they will gain a preliminary idea about the instrumentation and operating methods of chromatography. They can also analyze the chromatogram for identification of different components.

Marks: 10+40

UNIT I: Introduction to Chromatography: Introduction, general idea about chromatography, classification of chromatographic technique, development of chromatograms Paper Chromatography Principle, types and theory of paper chromatography, Rf, Rx and Rg values, technique, two dimensional paper chromatography, quantitative estimation, sources of error, precautions, applications, experimental chromatography

UNIT II: Column Chromatography: Introduction, principles of adsorption chromatography,

experimental requirement, identification of compounds, applications, experimental column chromatography, chiral chromatography. Thin layer Chromatography Superiority of TLC, theory of TLC, the technique of TLC, various types of TLC, two dimensional TLC, experiments in TLC, applications of TLC, analysis of food stuffs by TLC, High performance thin layer chromatography.

UNIT III: Partition Chromatography: Solvent system, procedure, theory of partition chromatography, column efficiency, applications, liquid-liquid partition chromatography, reverses phase partition or extraction chromatography, application. High performance liquid chromatography Introduction, characteristic features of HPLC, instrumentation for HPLC, Detectors used in HPLC, quantitative analysis and data display, derivatization technique in HPLC, Application of HPLC.

Unit IV: Gas Chromatography: Principle and theory of gas chromatography, instrumentation, ionization detectors, procedure, Evaluation of gas chromatograms, Identification of chromatograms, Gas-solid chromatography, application of GC. Ion Exchange Chromatography Ion-exchangers, Cation exchange resins, Ion exchange equilibrium, anion exchange resins, factors affecting ion exchange equilibrium, instrumentation, technique for ion exchange, ion chromatography, instrumentation, applications.

Books and References:

1. Ion exchange chromatography. Ed. H. F Walton, Hutchenvon and Rossing
2. Ion Exchange Separation in analytical chemistry, O. Sammuelson John Wiley 2nd ed 1963
3. Ion Exchange, McGraw-Hill, 1962.
4. Solvent Extraction and exchange. J Marcus

PAPER-XIII (CA-2.3.13)

SPECTROSCOPY 1

***Learning Objectives*:** The objective of this course is to introduce students to Atomic Absorption spectroscopy, Flame Emission spectroscopy, X-ray Spectroscopy. A brief introduction, basic principle, method of operation and applications of all these spectroscopic methods are discussed in this course.

***Learning Outcomes*:** This paper will ensure that the students shall get a thorough knowledge about the above mentioned spectroscopic methods. They will be able to apply these methods for analysis

of materials to extract useful structural and chemical information.

Marks-10+40

UNIT I: Atomic Absorption spectroscopy: Introduction, principle of AAS, absorption of radiant energy by atoms, classification of AAS methods, measurement of atomic absorption department, instrumentation, detection limits, interference in AAS, Applications. Atomic Emission spectroscopy Introduction, advantage and disadvantage of AES, origin of spectra, principle of emission spectroscopy, instrumentation, measurement of light intensity, applications.

UNIT II: Flame Emission spectroscopy: Principle, flame and flame temperature, excitation profiles and chemical reactions in flames, spectra of metals in flame, instrumentation, factors affecting intensity of emitted radiation, interference in flame photometry, applications, limitations. Photoelectron spectroscopy Principle, koopman's theorem, types of PES, chemical shifts in ESCA, instrumentations for PES, Technique of PES, Atomic and molecular photoelectron spectra, Applications of ESCA, Auger electron spectroscopy, AES instrumentations, Applications of AES.

UNIT III: Polarimetry: Polarimeter, optical rotator dispersion, circular dichroism Introduction, Polarized light, optical activity, application of polarimetry, ORD and CD, Rotatory dispersion, instrumentation for ORD and CD, cotton effect, Relationship between ORD and CD, the octant rule, application of octant rule, application of ORD and CD, advantage and disadvantages. Nephelometry, turbidimetry Light scattering, principles of nephlometry and turbidimetry, instrumentations, general procedure for operating nephelometer, applications.

UNIT IV: X-ray spectroscopy: Mosley's law, interaction of X-ray with matter, auger process, X-ray instrumentations, X-ray absorption and emission method, X-ray diffraction, generation of X-ray, miller indices, Bragg's condition, Laue method, Rotating crystal method, Debye and Scherrer powder method, scattering factors, identification of unit cell, systematic absences, predicting diffraction pattern of lattices, phase problem.

Books and References:

1. Instrumental methods of Analysis. H. H. Willard. Meriu Jr. And J. A. Dean
2. Principle of Instrumental analysis – Skoog and west

3. Instrumental methods of analysis. B. K. Sharma, Goel Publishing House,

Meerut

4. Instrumental Methods of Analysis of- Chatwal and Anand

5. Basic Principle of Spectroscopy: R Chang. Mc Graw Hil

PAPER-XIV (CA-2.3.14)
(PHYSICAL CHEMISTRY-III, INTERDISCIPLINARY-I)

Learning Objectives: This course deals with molecular spectroscopy such as rotational, vibrational, electronic and ESR. This course also introduces instrumental methods of analysis in XRD, IR, polarography, thermal analysis

Learning Outcomes: After course completion, students will have a knowledge on various spectroscopic instruments and the analysis of data. The students will also have a proper understanding of molecular spectroscopy and their application to different molecules.

Marks: 10+40

UNIT-I Spectroscopy: (a) Rotational Spectroscopy The rigid diatomic rotor, selection rules, intensity of rotational transitions, the role of rotational level degeneracy, the roleof nuclear spin in determining allowed rotational energy levels. Classification of polyatomic rotors and thenon-rigid rotor. **(b) Vibrational Spectroscopy:** Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strength; anharmonicity, Morse potential energy diagram, vibration- rotation spectroscopy. Breakdown of Oppenheimer approximation, vibrations of polyatomic molecules, Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities; metal-ligand vibrations.

UNIT-II (a) Electronic Spectroscopy: Electronic transitions, Franck-Condon principle. Vertical transitions. Selection rules, parity, symmetry and spin selection rules. Polarization of transitions. Fluorescence and phosphorescence.**(b) Raman Spectroscopy:** Classical and quantum theories of Raman effect Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Mutual exclusion principle.

UNIT-III Electron Spin Resonance (ESR) spectroscopy: g-factor, electron-nuclear coupling, double resonance in ESR electron-electron coupling. Techniques of ESR spectroscopy **Mössbauer Spectroscopy:** Basic principles, instrumentation, spectral parameter and displays, applications. Mossbauer parameters- isomer shift, quodropole splitting, Magnetic hyperfine interaction, Doppler effect. Applications of Mossbauer

spectroscopy.

UNIT-IV Electron Diffraction: Principle, Scattering intensity and scattering angle, Wierl equation, Measurement technique, Elucidation of structure of simple gas phase molecules, Election diffraction studies of some compounds, Low energy electron diffraction (LEED) and structure of surface Neutron Diffraction Introduction, Theory of neutron diffraction, Scattering of neutrons by solids and liquids, Magnetic scattering, Measurement technique, Elucidation of structure of magnetically ordered unit cell, Applications

Books and References:

1. *Fundamentals of Molecular Spectroscopy*: C. N. Banwell, McGraw-Hill.
2. *Basic Principles of Spectroscopy*: R. Chang, Mc Graw Hill
3. *Application of spectroscopy of organic compounds*, J. R. Dyer, Prentice hall
4. *Spectroscopic methods in organic che*mistry, D. H. Williams, I. Fleming, Tata McGrawHill.
5. *Organic spectroscopy*, W. Kemp, ELBS
6. *Spectroscopy of organic compounds*, P. S. Kalsi, New Age International.
7. *Mössbauer Spectroscopy and Transition Metal Chemistry*, P. Gütlich, R. Link, A. Trautwien, Springer-Verlag (1978).
8. *Mössbauer Spectroscopy*, N. N. Greenwood, T. C. Gibb, Chapman and Hall Ltd. (1971).

PAPER-XV (CA-2.3.15)
(GENERAL CHEMISTRY-IV: PRACTICAL)

Learning Objectives: This course is designed to introduce students with chemical kinetics, energy of activation, saponification experiments and Adsorption experiments. Determination of acid and basic strength by electrochemistry is also included.

Learning Outcomes: This course ensures that the students shall be able to study surface tension. They should be able to perform electrochemical analysis of acids and bases.

Marks = 50 **Time: 3 hr**

Chemical Kinetics:

1. Saponification of ethylacetate with sodium hydroxide by chemical method.
2. Comparison of strength of acids by ester hydrolysis

Adsorption:

1. Adsorption of acetic acid and oxalic acid on animal charcoal and verification of Freundlich isotherm.

Phase equilibria:

1. Determination of critical solution temperature of phenol-water system.
2. Construction of phase diagram for a three component system (chloroform-acetic acid – water).

Electrochemistry:

1. Determination of strength of strong acid and weak acid in given mixture conductometrically.
2. Estimation of ferrous iron in ferrous ammonium sulphate potentiometrically.
3. Potentiometric titration of a strong acid with strong base using quinhydrone electrode.
4. Verification of Beer's law.

Analytical

1. Chemical Analysis of cement - free lime and total calcium in cement.
2. Chemical Analysis of cement-silica
3. Determination of chemical composition of cement
4. Determination of Hardness of water
5. Determination of Dissolved oxygen (D.O), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

Books and References:

1. *Experimental physical chemistry*: R. C. Das and B. Behera, Tata McGraw Hill.
2. *Findlay's practical chemistry (revised)*: B. P. Levitt, Longman.
3. *Advanced practical physical chemistry*: J. B. Yadav, Goel publishing house, Meerut.

SEMESTER-IV
PAPER-XVI (CA-2.4.16)
ELECTROANALYTICAL METHOD

***Learning Objectives*:** The focus of this course is to introduce students to Coulometry, Amperometry, Potentiometry and Electrogravimetry. A brief introduction, basic principle, method of operation and applications of all these tools are discussed in this course. The major advantages and disadvantages are also covered in this course.

***Learning Outcomes*:** This paper will ensure that the students shall get a thorough knowledge about the above mentioned analytical methods. They will be able to apply these methods for analysis of samples. They will be able to get some preliminary hand on for these instruments as well.

Marks-10+40

UNIT I: Coulometric method: Principle, Coulometric techniques, coulometric determination, advantages, instrumentation for coulometric titrator, applications, determination involving coulometric titrations at constant current, potentiostatic coulometry, applications of controlled potential coulometry. Conductometric method Conductance, measurement of conductance, electrodeless conductivity meters, applications, conductometric titrations.

UNIT II: Amperometry: Principle, amperometric titration curves, amperometric indicators, Instrumentations, procedure for amperometric titrations, bioamperometric titrations, advantages, applications. Voltammetry and polarography Voltammetry, principle of polarography, instruments, polarographic measurements, , DME, HMDE, Polarogram, halfwavepotential, current contribution to the polarographic wave, departure from diffusion limited currents, evaluation of polarographic waves, application of polarography, chronopotentiometry, cyclic voltametry.

UNIT III: Potentiometry: Introduction, electrochemical cells, fundamental of potentiometry, electrode systems, accuracy of direct potentiometric measurements, limitations of direct potentiometry, potentiometric titrations, method of end point location, types of potentiometric titrations, advantages. Oscillometry Theory, instrumentation, high frequency titrimeters, applications, advantages.

UNIT IV: Electrogravimetry: Theory, electrogravimetric methods, instrumentations, electrolysis

using a mercury cathode, spontaneous or internal electrolysis, Determination of metal by constant current procedure , determination of metals by controlled potential methods. pH measurements Definition, buffer solution, electrometric determination of pH, potentiometric determination of pH, Reference electrode, pH indicator electrode, glass electrode, ion selective electrode, solid membrane electrode, gas sensing electrode, ion selective field effect transistors, electrode interference, Instrumentation and applications.

Books and References:

1. Bockris, J. O. M. Reddy, A. K. N. Modern electrochemistry, I: Plenum Press: New York, 1970.
2. Bard, A. J. ., Fulkner, L. R., Electrochemical Methods: Fundamental and applications, 2nd edition, John Wiley and sons: New York, 2001
3. Principles of Electroanalytical Methods, Tom Riley, Colin Tomlinso

PAPER-XVII (CA-2.4.17)

POLYMER AND NANOTECHNOLOGY

***Learning Objectives*:** The focus of this course is to introduce students to polymers and nanomaterials, their synthesis by different routes and characterization. Studies related to their chemical and physical properties are also discussed in this course.

***Learning Outcomes*:** After course completion, the students are expected to be able to synthesize thin films, nanomaterials and various polymeric composites. They will also get concrete idea of physical properties of polymers and different classes of nanomaterials.

Marks-10+40

UNIT I: Polymer analysis: Introduction to polymers: Brief history to polymers, how polymers are made, classification of polymers Analysis and testing of polymers: Chemical analysis of polymers: X-ray diffraction analysis, thermal analysis, TGA, DTA. Physical testing of polymers: Mechanical properties, Fatigue testing, impact testing, tear resistance, hardness, abrasion resistance. Thermal properties: Softening temperature, flammability.

UNIT II: Optical properties: transmittance, color, gloss, haze and transparency. Electrical properties: dielectric constant and loss factor, resistively, dielectric strength, electronic properties.

Chemical properties: resistance to solvents, vapor permeability, weathering. Measurement of molecular weight and size: End group analysis, colligative properties measurements, solution viscosity and molecular size.

UNIT III: Carbon Nanostructures and Applications of Nanotechnology: Carbon Nanostructures Introduction, carbon molecules, carbon clusters, carbon nanotubes, application of carbon nanotubes Biomedical applications Introduction, biological sciences, photodynamic therapy in targeted drugs, advances in manufacturing, biomedical sensor and biosensors, quantum dot technology in cancer treatment, nanoparticle as a drug carrier

UNIT IV: Dimension in nano technology: 0, 1, 2, 3 dimensional nano materials (quantum dots, nano wires, nanotubes, nanorods. Graphene Environmental impacts of nanotechnology Introduction, engineered nonmaterial's in the body, routes of entry, toxic mechanisms, environmental implications of nanoparticles, toxicological health effects, relevant parameters in nanoparticle toxicology, integrated concept of risk assessment of nanoparticles.

Books and References:

1. The text book of Polymer Science by F. W. Bilmayer
2. Polymer Science by Gowarikar
3. Introduction to polymer science and chemistry by M. Chand, Taylor and Francis Publication.
4. A text books of polymers by M. S. Bhatnagar
5. T. Varghese, K. M. Balakrishna, Nanotechnology, Atlantic Publishers, 2012.

PAPER-XVIII (CA-2.4.18)
ANALYSIS OF MATERIALS II

***Learning Objectives*:** This paper aims to introduce the students to different analytical methods used in the analysis of food, drug and ore and their compositions. This course also deals with classification, and qualitative and quantitative estimation of food, drug and ores. It also introduces application of analytical methods in forensic science.

***Learning Outcomes*:** This paper will ensure that the students learn to analyze and classify the above mentioned materials. After completing this course they will be able to do the sampling and chemical

analysis of these materials for ensuring the quality and standard of these materials.

Marks-10+40

UNIT I: Analysis of food: Fuel value of food and importance of food nutrients Food Additives – General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour. Analysis of Milk – Fat content, proteins, acidity, bacteriological quality and milk adulterants. Analysis of Oils and Fats – acid value, sap value, iodine value. Determination of rancidity and antioxidants. Analysis of spices (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils.

UNIT II: Analysis of Drug: Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests. Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies. Polymers in pharmaceuticals and novel drug delivery systems.

UNIT III: Forensic Science: Analytical Chemistry in Forensic Science: General idea. Forensic Analysis: Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification. Analytical Toxicology: Isolation, identification and determination of: Narcotics: Heroin, morphine and cocaine. Stimulants: Amphetamines and caffeine, LSD, Viscera, stomach wash, vomit and postmortem blood for poisons like – cyanide, arsenic, mercury, insecticides and pesticides.

UNIT IV: Analysis of Ore: General techniques of analysis applied to complex materials - Scope of metallurgical analysis - General methods of dissolution of complex materials - Various chemical methods for the effective separation of the constituents in the complex materials. Analysis of ores: Iron ore- Analysis of the Constituents – Moisture , loss of ignition, Total Iron, ferrous Iron ,Ferric Iron, alumina , silica, Titania, Lime, Magnesia, Sulphur, phosphrous, manganese, alkalies, combined water, Carbon in blast furnace, flue dust and sinter. Manganese Ore - Analysis of the Constituents – Total Manganese, MnO_2, SiO_2, BaO. Fe_2O_3, Al_2O_3, CaO, P and S Chromite Ore - Analysis of the Constituents – Chromium, SiO_2, FeO, Al_2O_3 CaO,& MgO. Aluminium Ore (Bauxite) - Analysis of

the Constituents – Silica, Alumina, Fe_2O_3,Titania, MnO, P_2O_5, CaO, MgO, vanadium, zirconium, and alkalies.

Books and References:

1. Manual procedure for chemical and instrumental analysis of ores, minerals, and ore dressing products. Government of India Minstry of steel and mines, Indian Bureau of Mines. 1979.
2. Chemical analysis of metals: sampling and analysis of metal bearing ores: American Society of for testing and materials 1980- Technology and engineering
3. Alloying: Understanding the basics. Cited by Joseph R. Davis, ASM International (2005)
4. Chemical Analysis of Drugs. Takeru Higuchi. Interscience Publishers. 1995.
5. The handbook of Drug laws. M. L. Mehra. University Book Agency, Ahmedabad. 1997

PAPER-XIX (CA-2.4.19)
QUALITY IN ANALYTICAL CHEMISTRY AND DIFFERENT MATERIAL ANALYSIS DATA HANDLING

***Learning Objectives*:** This paper aims to introduce the students to different analytical methods for quality determination of materials and control the standard. More importantly it discusses the methods to interpret the result and representation of data obtained from analytical experiments.

***Learning Outcomes*:** After completion of this paper the students will learn to use different analytical methods to obtain data to analyze and classify different sample materials. After completing this course they will be able to do the interpretation of data to determine the quality as well as representation of results in different forms.

Marks-10+40

UNIT I: Quality control Characteristics of an analysis: quality of an analytical procedure, limit of detection, sensitivity, safety, cost measurability, selectivity and specificity, quality control-principles of Ruggedness test, control charts, Youden plot, and ranking test.

UNIT II: Evaluation and reliability of analytical data: limitation of analytical methods, accuracy, precision, Errors in chemical analysis, classification of errors, minimization of errors, significant

figures, computations and propagation of errors. Statistical analysis: Mean deviation, Standard deviation, coefficient of variance, normal distribution, F -test, T -test, rejection of results, presentation of data.

Unit III: Quality assurance Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results. Signal to noise: Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction and software methods of noise reduction.

UNIT IV: Quality assurance and management systems: Elements of quality assurance, quality assurance in design, development, production and services, quality and quantity management system, ISO 9000 and ISO 14000 series-meaning of quality, quality process model, customer requirement of quality calibration and testing, statistical process control, process control tools, control chart, statistical quality control, acceptance sampling.

Books and References:

1. K.V.S.G Murali Krishna, An Introduction ISO 9000, ISO 1400 Series, Environmental Management

2. Quality Assurance and Good Laboratory Practices, Prof. Y. Anjaneyulu, In Now Publication, New York

3. Quality Assurance in Analytical Chemistry – G.Kateman and F.W Pijpers, John Wiley and Sons, New York CA 2.4.20 Project

PAPER-XX (CA-2.4.20)
Dissertation

Marks – 100

The dissertation shall comprise of conducting a small project under faculty members of the department. The title and execution of the project work shall be decided in consultation with the faculty members of the department by a committee constituting HOD and other senior faculty members. The committee may also extend the provision of co- opting the external guide as per the provision provided by the Ravenshaw University.

In general, the student is expected to do literature survey in the assigned topic, and to do somekind of experimental investigation, and result analysis. However, final decision regarding the execution of project work rests with the supervisor/co-supervisor and the committee on mutualdiscussion to the best benefit of the student for academic career. The guideline provided by UGC shall be also taken into account in this regard.