

Ewing Christian College, Allahabad
DEPARTMENT OF CHEMISTRY

M.Sc. Chemistry – Semester I
Theory Paper I: Inorganic Chemistry

Core Course Code: CHE1TH01

Course Credit= 04
(40 Lectures)

✓ UNIT-1

COORDINATION CHEMISTRY: Theories of Coordinate Linkages: Valence Bond, Crystal Field, Ligand Field and M.O Theory. Crystal Field splitting of d – orbitals in octahedral, trigonal bipyramidal, square pyramidal, tetragonal and square fields. Crystal field stabilization energy (CFSE). M.O. Energy level diagram for octahedral and tetrahedral complexes (with s bonding only). Spectrochemical series. Jahn Teller effect.

UNIT-2

STABILITY OF METAL COMPLEXES IN SOLUTION: Step wise and overall stability constants. Thermodynamic correlations. Determination of stability constants, Job's method of continuous variation and mole ratio method. Factors affecting the stability constants, chelation and its importance.

UNIT-3

CHEMISTRY OF f – BLOCK ELEMENTS: Comparative study of Lanthanides and Actinides with special reference to electronic structure, oxidation state, coordination number, structure, stereochemistry and magnetic and spectral properties. General chemistry of Actinides including EFM diagrams.

✓ UNIT-4

SOFT AND HARD ACIDS AND BASES: Pearson's concepts, SHAB Principle and its applications.

UNIT-5

MOLECULAR LUMINESCENCE: Principles of fluorescence, phosphorescence, photoluminescence spectra of transition metal (d^{10}) and Lanthanide complexes.

M.Sc. Chemistry – Semester I
Theory Paper II: Organic Chemistry

Core Course Code: CHE1TH02

Course Credit= 04
(40 lectures)

UNIT – I

Aromaticity and π -Molecular Orbitals of Conjugated Systems

Aromaticity in benzenoid, non-benzenoid compounds and metallocenes, Huckels rule, energy of pi-molecular orbitals, annulenes, anti-aromaticity, homo-aromaticity.

Reaction Mechanism: Structure and Reactivity

Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects, Product analysis, Kinetic and stereochemical studies.

UNIT – II

Stereochemistry

Elements of symmetry, chirality, molecules with more than one chiral centre, threo and erythro isomers, optical purity, enantiotopic and diastereotopic atoms, group and faces, stereospecific and stereoselective synthesis. Optical activity in the absence of chiral carbon (biphenyls allenes and spiranes), chirality due to helical shape, R/S Nomenclature, chiral centres and chiral molecules.

UNIT – III

Conformational Analysis

Factors responsible for the stability of conformation, Torsional strain, steric strain, Dipole-dipole interaction, Hydrogen bonding, angle strain, hyperconjugation, and anomeric effect. Conformation of $\text{CH}_2\text{OH}-\text{CH}_2\text{OH}$, 2-chloroethanol, haloalkanes, 1,2-difluoroethane, confirmation of cyclohexanone- $A^{1,2}$ strain, cyclohexene and Confirmation of alkylidenecyclohexane- $A^{1,3}$ strain. Conformational analysis of cycloalkanes- disubstituted cyclohexanes, decalins. Effect of conformation on reactivity.

UNIT – IV

Aliphatic Nucleophilic Substitution

The $\text{S}_{\text{N}}2$, $\text{S}_{\text{N}}1$, mixed $\text{S}_{\text{N}}1^1$, $\text{S}_{\text{N}}2^1$, $\text{S}_{\text{N}}i$ and SET mechanisms,

The neighboring group mechanism, neighboring group participation by P and S bonds, anchimeric assistance.

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

UNIT – V

Reaction intermediate

Generation, structure, stability and reactivity of nucleophilic carbenes, carbanion (enolate ion), non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangement

Aromatic Nucleophilic Substitution The $\text{S}_{\text{N}}\text{Ar}$, $\text{S}_{\text{N}}1$ benzyne and $\text{S}_{\text{RN}}1$ mechanisms, Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser and Smiles rearrangements.

M.Sc. Chemistry – Semester I
Theory Paper III: Physical Chemistry

Core Course Code: CHE1TH03

Course Credit= 04
(40 Lectures)

Unit 1

MOLECULAR SPECTRA: Basic concepts of molecular spectroscopy, Classification of spectra, Characterization of electromagnetic radiations, Regions of the Spectrum

Rotational Spectra: Rigid and non-rigid rotation spectra-selection rule, Centrifugal distortion, Isotopic shift, Spectra of polyatomic molecules, Rotational function, Experimental techniques

Unit 2

VIBRATION ROTATION SPECTRA: Simple harmonic oscillator, Vibrational energy, Anharmonicity, Principle of vibration-rotation spectra, Selection rules PQR branches, Vibration in polyatomic molecules, Effect of nuclear spin, Isotopic shift, Group frequency, Experimental techniques.

Unit 3

THERMODYNAMICS: Nernst heat theorem and calculation of ΔG from ΔH , obtained calorimetrically. Statements of third law of thermodynamics, Applications of the third law. Interpretation of unattainability of absolute zero of temperature by the third law. Determination of entropy from the third law and entropy corrections due to gas imperfections. Consequences of the third law (o-p hydrogen and liquid He-II), Test of the third law, violation of third law, residual entropy.

Unit 4

CHEMICAL KINETICS: Thermodynamic formulation of rate constant, Comparison of collision and absolute reaction rate theories, Calculation of transmission coefficient, Transition state theory in solution, Primary and secondary salt effects in the light of mechanistic steps. The theory of absolute reactions between atoms and reactions between molecules in terms of partition function, influence of ionic strength and dielectric constant, Explosive reactions, Acid-base catalysis

Unit 5

ELECTROLYTES: Limitation of Arrhenius theory of electrolytic dissociation, Role of solvent and inter-ionic forces, Activities and activity coefficients, Determination of activity coefficient, Debye-Huckel theory of the structure of dilute ionic solution, Charge density and electrical potential, Properties of ionic cloud, Activity coefficient from Debye-Huckel theory, Limiting law and its verification, Thermodynamic properties of electrolytic solutions and Debye-Huckel theory, Weak electrolytes and Debye-Huckel theory to more concentrated solutions partial molar quantities of electrolytic solutions, Determination of partial molar volume

M.Sc. Chemistry – Semester I
Theory Paper IV: Analytical Chemistry

Core Course Code: CHE1TH04

Course Credit= 04
(40 Lectures)

UNIT 1

Fundamentals of Chemical: Qualitative and quantitative analysis, sensitivity and selectivity of analytical methods, sampling, hydrogen ion exponent: buffer solutions, pseudo buffers, standard buffers: problems based on acid-base, solubility and complex ion equilibria.

UNIT 2

Data Handling in Analytical: accuracy and precision, determinate and indeterminate errors, significant figures, rounding off figures, standard deviation, propagation of errors, regression analysis, statistics of sampling and detection limit evaluation.

UNIT 3

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Volumetric Methods of Analysis: Expression of concentration of solutions: Molarity, formality, normality; analytical and equilibrium concentrations; common units for expressing trace concentrations; standard solutions, volumetric calculations; acid-base, redox, precipitation, complexometric and chelatometric titrations; theory of indicators-mixed indicators and fluorescent indicators.

UNIT 4

Gravimetric Methods of Analysis: weight relationships; principles and scope of gravimetric methods; conditions of impurities in precipitates- coprecipitation and post precipitation; washing, filtering and drying of precipitates; role of organic precipitants in gravimetric analysis, important organic precipitants: dimethyl glyoxime, cupferron, 8-hydroxy quinoline, salicyldoxime, 1-nitroso 2-naphthol, anthranic acid, α -benzoinoxime (cupron), sodium tetraphenylboron.

UNIT 5

Spot tests: spot tests for metal ions, spot tests for identification of functional groups- hydroxyl, carboxylic, nitro, nitroso, azo and amino.

Determination of Elements and Functional Groups in Organic Compounds: Semi micro determination of carbon, hydrogen, sulphur and nitrogen

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M.SC. CHEMISTRY – SEMESTER I
PRACTICALS- LAB COURSE

INORGANIC CHEMISTRY

LAB COURSE CODE: CHE1PR01

Course Credit: 02
(40 Hrs)

Qualitative Analysis: Qualitative mixture analysis for seven radicals including two rare elements. (Mo, W, Ti, Zr, Th, Ce, V) in cationic and anionic forms.

Quantitative separation and determination: Following pairs of metal ions using gravimetric and volumetric methods

- (i) Ni²⁺ (gravimetrically) and Cu²⁺ (volumetrically)
- (ii) Ba²⁺ (gravimetrically) and Cu²⁺ (volumetrically)
- (iii) Fe³⁺ (gravimetrically) and Ca²⁺ (volumetrically)
- (iv) Mg²⁺ (gravimetrically) and Ca²⁺ (volumetrically)

ORGANIC CHEMISTRY

LAB COURSE CODE : CHE1PR02

Course Credit : 02
(40 Hrs)

- (a) Separation and identification of organic compounds using chemical methods from binary mixtures.
- (b) Estimation of glucose, aldehydes and ketones by chemical and spectroscopic methods.

PHYSICAL CHEMISTRY

LAB COURSE CODE : CHE1PR03

Course Credit : 02
(40 Hrs)

1. Kinetic studies of a reaction between acetone and iodine catalysed by H⁺ ions
2. Kinetics of oxidation of reducing sugars by potassium ferricyanide in presence of ammonium hydroxide or sodium hydroxide.
3. Kinetics of oxidation of lactose/ maltose by potassium ferricyanide in presence of sodium hydroxide.
4. Potentiometric titration of strong acid and strong base.

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ANALYTICAL CHEMISTRY

LAB COURSE CODE : CHE1PR04

Course Credit : 02
(40 Hrs)

1. Determination of replaceable hydrogen in acid by titration with sodium hydroxide
2. Determination of bicarbonate
3. Determination of water hardness with EDTA
4. Determination of Silver by Volhard's method
5. Determination of Chloride by Fajan's method
6. Analysis of Commercial hypochlorite or peroxide solution by iodometric titration

M.Sc. Chemistry – Semester II
Theory Paper I: Inorganic Chemistry

Core Course Code: CHE2TH01

Course Credit= 04
(40 Lectures)

* UNIT-1

Molecular Symmetry: Symmetry elements and operations, symmetry groups, defining properties of a group, character tables and its applications. The great orthogonality theorem and its importance. Symmetry considerations in simple inorganic and coordination compounds.

* UNIT-2

Term Symbols and Basic Principles of Electronic Spectroscopy: Frank – Condon principle, spin and Laporte selection rules, band intensities, band width. Number of microstates and term symbols for gaseous atoms/ions. Spin-orbit coupling in spectroscopic ground state of p^2 and d^2 configurations and energies of J levels.

* UNIT-3

Electronic Spectra of Transition Metal complexes: Interpretation of electronic spectra, using Orgel and Tanabe-Sugano diagram for 3d Transition Metal complexes. Calculation of crystal field and ligand field parameters (Dq , B and β parameters), nephelauxetic series and charge transfer spectra.

* UNIT-4

Reaction Mechanism of Transition Metal Complexes: Inert and Labile complexes, mechanism of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct indirect evidence in favor of conjugate mechanism

* UNIT-5

Reaction Mechanism: Anation reactions, reactions without metal-ligand bond cleavage, substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reactions: redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.

M.Sc. Chemistry – Semester II
Theory Paper II: Organic Chemistry

Core Course Code: CHE2TH02

Course Credit= 04
(40 lectures)

UNIT-I

Free Radical Reactions

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes, Free radical rearrangement, Hunsdiecker reaction.

Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspect of addition reaction involving electrophiles, nucleophiles and free radicals, regio and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydroboration, Michael reaction, Sharpless asymmetric epoxidation, Stereochemistry of epoxidation and halo-lactonisation.

UNIT-II

Addition to Carbon-Hetero Atom Multiple Bonds

Generation of enolate ions and their synthetic applications. Stereochemistry of Wittig reaction and Aldol condensation. Stobbe condensation reactions. Hydrolysis of esters.

Elimination Reactions

The E₂, E₁ and E_{1cB} mechanisms and their stereochemistry and orientation. Reactivity-effects of substrates, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination and Peterson elimination.

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-conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems.

UNIT-IV

Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3-dipolar cycloadditions and cheletropic reactions.

UNIT-V

Sigmatropic rearrangement

Suprafacial and antarafacial shift of H, sigmatropic shifts involving carbon moieties, retention and inversion of configuration, (3,3) and (5,5) sigmatropic rearrangements, detailed treatment of Claisen and Cope-rearrangements. Fluxional tautomerism, Aza-

ENE REACTION. PROBLEMS ON PERICYCLIC REACTION

M.Sc. Chemistry – Semester II
Theory Paper III: Physical Chemistry

Core Course Code: CHE2TH03

Course Credit= 04
(40 Lectures)

• UNIT 1 (1)

QUANTUM CHEMISTRY: Origin of quantum theory, Black body radiation, Wein and Rayleigh Jeans laws, Planck's law and energy of harmonic oscillator, Postulate of quantum mechanics, Three dimensional time independent Schrodinger wave equation Eigen functions and Eigen values particle, Normalization and orthogonality conditions, One dimensional harmonic oscillator, Tunnel effect, Eigen function and Eigen value of H-atom, (Solutions not required), Shapes of s, p, d & f orbitals.

Approximate Methods- Variation principle and its applications to ground state H-atom, radial and angular distribution curves for H-atom.

UNIT 2

STATISTICAL MECHANICS: Quantum states and complexions, The combinatory rule, System with definite total energy, Degeneracy of energy levels probability and most probable distribution, Indistinguishability, Maxwell-Boltzmann statistics, partition function, Translation, rotational, vibrational and electronic partition functions, Internal energy and heat capacity in terms of partition function.

• UNIT 3 (13)

CHEMISTRY OF MACROMOLECULES: Introduction to type of polymers, Step polymerization, Statistical approach to Gelatin, Molecular weight distribution in linear polycondensation (Derivation of size distribution), Molecular weight averages, Methods of determining the molecular weight by osmotic pressure, light scattering, Sedimentation and viscosity methods.

• UNIT 4 (12)

SOLID STATE: The crystal system, Properties of Crystals, Basic laws regarding the forms of crystals, The structure of crystal, Crystal lattices, Symmetry, Lattices and unit cells, Miller indices, X-ray diffraction studies of crystals, The Laue and Bragg methods of crystal analysis, X-ray analysis of NaCl, Determination of Avogadro number from X-ray analysis.

UNIT 5

PHOTOCHEMICAL REACTIONS: Absorption of light, chain reaction, free radical chain reaction, Rice Herzfield mechanism for the decomposition of ethane, Lambert's Beer's Law, Grothaus Draper Law, Einstein's Law of photochemical equivalence, quantum efficiency, reasons for low and high quantum yields, kinetics of some photochemical reactions (decomposition of acetaldehyde, dimerisation of anthracene, etc.) photoelectric cell, photosensitization.

M.Sc. Chemistry – Semester II
Theory Paper IV: Analytical Chemistry

Core Course Code: CHE2TH04

Course Credit= 04
(40 Lectures)

UNIT 1 8-9

Ionic Equilibria in Solutions: Activity and activity coefficients, equilibrium constants in analysis and systematic approach to equilibrium calculations, mass balance equations and charge balance equations, numerical problems based on ionic equilibria.

UNIT 2 1-9

Potentiometry: Potentiometric electrodes: Metal electrodes, metal-metal electrodes, metal-metal salt electrodes for measuring the salt's anion, redox electrodes, reference electrodes, potentiometric titrations, potentiometers and pH meter, glass pH electrode and its applications, alkaline error and acid error.

UNIT 3 1-9

Conductometric Methods: Principle of analysis, measurement of conductance, analytical applications of conductometry, conductometric titrations, high frequency titrations.

UNIT 4 1-9

Coulometry and Electrodeposition: Electrolysis at constant potential, electrolysis at constant current, coulometric methods of analysis, applications of coulometry, coulometric titrations and their applications.

UNIT 5 1-9

Spectrochemical Methods: Interaction of electromagnetic radiation with matter-electromagnetic spectrum, mode of absorption of radiation with matter; rotational, vibrational and electronic transitions; absorption by isolated chromophores, conjugated chromophores and aromatic compounds; absorption due to chelate formation and metal complex formation.

Beer's law and its deviations and its applications, mixture of absorbing species, spectrophotometric instrumentation- monochromators, sample cells, detectors, types of instruments- single beam spectrophotometers and double beam spectrophotometers, spectrophotometric error in measurements.

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M.SC. CHEMISTRY – SEMESTER II
PRACTICALS- LAB COURSE

INORGANIC CHEMISTRY

LAB COURSE CODE: CHE2PR01

Course Credit: 02
(40 Hrs)

Preparation of Coordination Complexes and their Characterization by m.p, elemental.
Analysis and molar conductivity measurements.

- (a) $\text{VO}(\text{acac})_2$ (e)
- (b) $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3] \cdot 3\text{H}_2\text{O}$
- (c) $\text{Na}[\text{Cr}(\text{NH}_3)_2(\text{SCN})_4]$
- (d) $\text{Mn}(\text{acac})_3$
- (e) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$
- (f) $\text{Hg}[\text{Co}(\text{SCN})_4]$
- (g) $[\text{Co}(\text{Py})_2\text{Cl}_2]$
- (h) $[\text{Ni}(\text{NH}_3)_6]$

Study of recorded UV- visible and IR of above prepared coordination compounds

ORGANIC CHEMISTRY

LAB COURSE CODE: CHE2PR02

Course Credit: 02
(40 Hrs)

- (a) Preparation of various organic compounds involving two or three steps employing different reactions viz. Aldol Condensation, reactions of enolate ions, oxidation reactions, Cannizzaro reaction, Molecular rearrangement reactions etc. With a view to give the student sufficient synthetic training in synthetic organic chemistry.
- (b) Isolation of :
 - (i) Caffeine from tea leaves
 - (ii) Eugenol from cloves

PHYSICAL CHEMISTRY

LAB COURSE CODE: CHE2PR03

Course Credit : 02
(40 Hrs)

1. Kinetics of oxidation of reducing sugars by Cu(II) in presence of ammonium hydroxide.
2. Kinetics of oxidation of cyclic ketones by alkaline hexacyanoferrate (III) catalysed by Rh (III) chloride
3. Potentiometric titration of weak acid and strong base
4. Kinetics of reaction between $K_2S_2O_8$ and KI

ANALYTICAL CHEMISTRY

LAB COURSE CODE : CHE2PR04

Course Credit : 02
(40 Hrs)

1. pH titration of unknown soda ash
2. Spectrophotometric determination of iron
3. Determination of nitrate in water by spectrophotometry
4. Spectrophotometric determination of manganese and chromium in mixture
5. Conductometric titration
6. Potentiometric titration

SEMESTER III - THEORY PAPER

SPECIALISATION IN INORGANIC CHEMISTRY

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE3TH01

PAPER - I

Bioinorganic Chemistry

(40 Lectures)

UNIT-I

I-10

Role of Metal Ions in Biological Systems
Photosystems; nitrogen fixation, Na⁺ / K⁺ pump.

UNIT-II

I-10

Complexes of Biological Significance
Metal complexes of porphyrins and phthalocyanin, Vitamin B₁₂ and B₆; chlorophylls.

UNIT-III

I-10

Metallo Proteins
Function, Electronic structure, bonding and stereochemistry of the active site -
(1) Natural oxygen carrying proteins -- Haemoglobin, Myoglobin, Hemerythrins and Hemocyanin
(2) Electron Transport Protein -- (a) Iron - sulfur Proteins - Rubredoxin and Ferredoxins (b) Cytochromes (types a, b and c)

UNIT-IV

I-10

Metallo enzymes -
Mo-containing Enzymes - Nitrogenase; Xanthine Oxidase, sulphite, Oxidase and Nitrate reductase (b) Iron-containing Enzymes - cytochrome -c- oxidase, catalases, Peroxidases, cytochrome-p-450

UNIT-V

I-10

Copper - containing Enzymes - Superoxide dismutase (SOD), Bovine Superoxide dismutase (BOD), ascorbic acid oxidase and (b) Zinc - containing Enzymes carboxy - peptidase A and B; carbonic anhydrase and Urease.

INORGANIC CHEMISTRY

M.Sc. SEMESTER – III

COURSE CODE – CHE3TH02

PAPER – II (Organometallic Chemistry)

UNIT – I

Classification of Organometallic Compounds based on hapticity and polarity of M – C bond. Nomenclature and General Characteristics.

UNIT – II

Complexes of σ – Donor π – Donor Organic Ligands

Transition metal Alkenyls, alkynyls(Carbenes and Carbynes).Preparation, bonding and structure of alkene, alkyne, allyl, dienyl and arene complexes.

UNIT – III

Reactions of Organometallic Compounds

Important Reactions with special reference to nucleophilic and electrophilic attack on ligands and to organic synthesis

UNIT – IV

Transition Metal compounds in Homogenous Catalysis and compounds with M – H bond

Transition Metal compounds in Homogenous Catalysis and compounds with M – H bond: Hydrogenation , Hydroformylation and Zeigler – Natta polymerization of olefins. Wacker Process, Hydrocarbonylation of olefins, Oxopalladation reactions, activation of C – H bond. Metal hydrides (Classical and Non – classical)

UNIT – V

Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^2 – olefins and η^3 – allyl and dienyl complexes.

SEMESTER III - THEORY PAPER

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE3TH03 PAPER – III

Coordination Polymers, Cages, Clusters and Nanostructures

UNIT-I

Coordination Polymers

Classification, types of metal-organic frameworks (MOFs), Synthetic strategies, characterization, properties and applications.

UNIT-II

I-7

Metal Carbonyls and related Compounds

Preparation structure and properties; bonding in metal carbonyls, variants of CO bridging vibrational spectra of metal carbonyls, principle reaction types of metal carbonyls, metal nitrosyl.

UNIT-III

Polyhedral Boranes

Higher boranes, carboranes, metallo-boranes and metallo-carboranes Structure and bonding in the light of Wade's and Jemmis' Rules.

UNIT-IV

Synthesis and applications of nanoparticles

Introduction of Nano Particles; its different methods for preparation; its applications to chemistry.

UNIT-V

Alkoxides Properties; structural aspects of various types of alkoxides – Industrial applications and catalytic aspects of metal alkoxides.

SEMESTER III - THEORY PAPER

SPECIALISATION IN ORGANIC CHEMISTRY

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE3TH04 PAPER - I

Rearrangements and Photochemistry

UNIT-I

Molecular Rearrangements

Migration to electron deficient carbon atom
Pinacole-Pinacolone rearrangement, Wagner-Meerwein rearrangement, Tiffenev-Demjanov ring expansion, Dienone-Phenol rearrangement, Benzil Benzilic acid rearrangement, Favorski rearrangement.

UNIT-II

Migration to electron deficient nitrogen atom
Wolf, Hofmann, Curtius, Losen, Schmidt, Beckmann rearrangement.

Migration to electron deficient oxygen atom
Baeyer-Villiger rearrangement.

UNIT-III

Photochemistry of Carbonyl Compounds:
Photochemistry of enones, hydrogen abstraction.

UNIT-IV

Rearrangements of α, β - unsaturated ketones and cyclohexadienones, photochemistry of p-benzoquinones.

UNIT-V

Photochemistry of unsaturated system
Olefins, cis-trans isomerisation, dimerisation, hydrogen abstraction and additions. Acetylenes-dimerisation, Dienes-photochemistry of 1, 3-butadiene (2+2) additions leading to cage structures, photochemistry of cyclohexadienes, Photochemistry of aromatic compounds-excited state of benzene and its 1,2 and 1, 3-shifts, Photo-Fries rearrangement, Photo-Fries reaction of anilides, photo substitution reaction of benzene derivatives, Photolysis of nitride esters and Barton reaction.

SEMESTER III - THEORY PAPER

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE3TH05 PAPER II

Oxidation, Reduction and Organometallic Reagents

UNIT-I

Oxidation

Hydrocarbons-alkenes, aromatic, rings, saturated, C-H groups (activated and unactivated), alcohols, diols.

UNIT- II

Aldehydes, ketones and carboxylic acids, amines, hydrazines and sulphides.
Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium (III) nitrate.

UNIT-III

Reduction

Hydrocarbons -alkenes, alkynes and aromatic rings.

Carbonyl Compounds : aldehydes, ketones, acids and their derivatives.

Epoxides :

Hydrogenolysis

UNIT-IV

Organometallic Reagents

Synthetic applications of organometallic compounds with mechanistic details of following metals.

Hg, Cd, Ce, Cu, Ni, Fe, Co, Rh, Cr and Ti

UNIT- V

Application of Pd(0) and Pd(II) complexes in organic synthesis - Stille, Suzuki and Sonogashira coupling, Heck reaction and Negishi coupling.

SEMESTER III - THEORY PAPER

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE3TH06 PAPER - III

Strategies in Organic Synthesis

UNIT-I

Disconnection Approach

General introduction to synthons and Synthetic equivalents, Disconnections, (C-C, C-S, C-O, bonds).

UNIT-II

Functional group interconversion, chemoselectivity, cyclisation reaction choosing synthetic route for small and large scale synthesis.

UNIT-III

Protecting Groups

Principle of protection of alcoholic, amino, carbonyl and carboxylic groups.

UNIT-IV

Stereochemistry in Organic Synthesis

Stereoselectivity and stereospecificity. Regioselectivity and regioselectivity :
Asymmetric synthesis- Sharpless asymmetric epoxidation.

UNIT-V

Synthetic Strategies :

- (i) For formation of carbon-carbon bond.
- (ii) For formation of carbon-nitrogen bond.
- (iii) For formation of carbon-halogen bond.
- (iv) For Ring Synthesis
- (v) For Multistep Synthesis

SEMESTER III - ELECTIVE PAPER

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE3TH14 PAPER - IV

Spectroscopy of Organic Compounds

UNIT-I

Nuclear Magnetic Resonance Spectroscopy

PMR Spectroscopy chemical exchange, effect of deuteration, complex spin-spin interaction between two, three four and five nuclei (first order spectra).

UNIT-II

Virtual coupling, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contract shift reagents, solvent effects. Fourier transform technique. Nuclear Overhauser Effect (NOE). Resonance of other nuclei : F and P. Structural problems based on PMR.

UNIT-III *Reas*

Carbon-13 NMR Spectroscopy

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. DEPT, INEPT, APT techniques. Two dimension NMR spectroscopy: COSY, NOESY and INADEQUATE techniques. Structural problem based on ^{13}C NMR.

UNIT-IV *AL*

Mass Spectrometry

Introduction, ion production-EI, CI, FD and FAB, factors, affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Mc-Lafferty rearrangement Nitrogen rule. High resolution mass spectrometry Examples of mass spectral fragmentation of organic compounds with respect of their structure determination.

UNIT-V

Structural problems by joint application of UV, IR, NMR (^1H & ^{13}C) and mass spectroscopy.

SEMESTER III - PRACTICALS CHEMISTRY

Inorganic Chemistry [in addition to CHE3TH01 , 02 , 03]

Course Credit = 04
(40 Lectures)

COURSE CODE – CHE3PR01

Separation of a Mixture of Cations/Anions by Paper Chromatographic Technique Using Aqueous/Non-aqueous Media:

- a. Pb^{2+} and Ag^+ (aqueous and non-aqueous media)
- b. Co^{2+} and Cu^{2+} (non aqueous media)
- c. Cl^- and I^- (aqueous – acetone media)
- d. Br^- and I^- (aqueous – acetone media)

Ion-exchange Method of Separation

- e. Separation of Zn^{2+} and Mg^{2+} on an anion exchanger
- f. Separation of Co^{2+} and Ni^{2+} on an anion exchanger

SEMESTER III - PRACTICALS CHEMISTRY

Organic Chemistry [in addition to CHE3TH04 , 05 , 06]

COURSE CODE – CHE3PR02

Course Credit = 02
(40 hrs)

- (a) Separation and identification of organic compounds using chemical methods from organic mixtures containing up to three components
- (b) Preparation of organic compounds involving several stages
- (c) Verification of Lambert Beer's Law using bromocresol green reagent.
- (d) Estimation of carbohydrates, protein, aminoacids, ascorbic acid, blood cholesterol and aspirin in APC tablets by UV-visible Spectrophotometric method.

Physical Chemistry [in addition to CHE3TH07 , 08 , 09]

COURSE CODE – CHE3PR03

Course Credit = 02
(40 hrs)

1. Kinetics of Pd(II) catalysed oxidation of reducing sugars by N-bromoacetamide in acidic medium.
2. Kinetics of oxidation of ketones by Ce(IV) sulphate in acidic medium catalysed by Ir(III) chloride .
3. Conductometric titration of mixtures of acid and base.
4. Determination of freezing point depression constant.
5. Determination of molecular weight of some electrolytes and non-electrolytes cryoscopically.

M.Sc. CHEMISTRY

SEMESTER IV - THEORY PAPER

SPECIALISATION in INORGANIC CHEMISTRY

PAPER - I

COURSE CODE - CHE4TH01

Course Credit = 04
(40 Lectures)

Structural Methods in Inorganic Chemistry

UNIT-I

NMR Spectroscopy (i) : Use of Chemical shifts and spin-spin couplings for structural determination; Double resonance, and Dynamic processes in NMR; Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in ^{13}C NMR; Use of Chemicals as NMR auxillary reagents (shift reagents and relaxation reagents); ^1H NMR of paramagnetic substances.

UNIT- II

Nuclear Spectroscopy - (ii) Multinuclear NMR of Metal nuclei. ^{31}P , ^9F , ^{27}Al , ^{11}B , ^{119}Sn , $^{203/205}\text{Tl}$, ^{51}V etc.

UNIT- III

Electron Spin Resonance Spectroscopy: Basic principle, Hyperfine Splitting (isotropic systems); the g value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Krammer's degeneracy); Electron-electron interactions, Anisotropic effects (the g value and the hyperfine couplings); Structural applications of transition metal complexes.

UNIT- IV

Infrared and Raman Spectroscopy: Basic Principle, Fundamental modes, Factors affecting vibrational frequency, Applications of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB_2 , AB_3 and AB_4 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, sulphate and ureas).

UNIT- V

Mass Spectrometry: Basic Principle, Fragmentation pattern and Fingerprint applications in the interpretation of Mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (ESI, TOF and FAB)

SEMESTER IV - THEORY PAPER

PAPER - II

COURSE CODE - CHE4TH02

Course Credit = 04
(40 Lectures)

Structural Methods in Inorganic Chemistry

UNIT- I

Magnetic Properties

Magnetic behaviours, recent methods of magnetic susceptibility measurements, anomalous magnetic properties of transition metal complexes, spin crossover phenomena, magnetic properties of binuclear metal complexes involving metal-metal exchange interaction (Bleaney-Bower equation).

UNIT- II

X-ray Photo electron Spectroscopy and Related Techniques

Basic principles, spectral features and their applications to structural determination of inorganic molecules and metal complexes: X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES).

UNIT- III

X-Ray Spectroscopy : X-ray Absorption Fine Structure Spectroscopy (EXAFS and XANES) with synchrotron radiations techniques and X-ray fluorescence (XRF).

UNIT- IV

UV Visible Spectroscopy

Theory and its applications to metal complexes

UNIT- V

Mossbauer Spectroscopy

Basic principle, conditions for Mossbauer spectroscopy, spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature dependent effects, structural deductions for iron and tin - complexes, miscellaneous applications.

Nuclear Quadrupole Resonance (NQR) - Theory and its applications.

SEMESTER IV - THEORY PAPER

PAPER - III

COURSE CODE - CHE4TH03

Course Credit = 04
(40 Lectures)

Selected Topics in Inorganic Chemistry

UNIT-I

(i) **Electron Microscopy**
SEM (Scanning electron microscopy), and TEM (Transmission electron microscopy).

UNIT- II

(ii) **Electron Microscope AFM** (Atomic force microscopy) & **STM** (Surface tunneling microscopy).

UNIT- III

Photochemistry of Transition Metal complexes
Photoreactions of inorganic complexes.

UNIT- IV

Electrochemical Methods
Cyclic voltammetry.

UNIT- V

Differential pulse voltammetry, anodic stripping voltammetry, chronoamperometry, coulometry.

SEMESTER IV - THEORY PAPER
SPECIALISATION in ORGANIC CHEMISTRY

PAPER - I

COURSE CODE - CHE4TH04

Course Credit = 04
(40 Lectures)

Biosynthesis and Chemistry of Natural Products

UNIT - I

Bio-synthesis of Natural Products

- (a) The acetate hypothesis; poly β -Ketoacids, Biosynthesis, Biogenesis. Primary and Secondary reactions involved in biosynthesis. Biosynthesis of poly- β -ketoacid
- (b) Isoprene rule, mevalonic acid from acetyl Co-enzyme A. Biosynthesis of mono, sesqui, di and triterpenes.
- (c) Shikimic acid pathway for biosynthesis of aromatic ring.
- (d) General biosynthesis of alkaloids.

UNIT - II

Terpenoids and Carotenoids

Classification, isoprene rule. Structure determination, stereochemistry, synthesis of the following representative molecules: citral, α terpenol, farnesol, santonin, abietic acid and β -carotene, menthol. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

UNIT - III

Alkaloids

General methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring. Structure, stereochemistry and synthesis of the following : Ephedrine, (+) nicotine, quinine and morphine. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

UNIT - IV

Steroids

Basic skeleton Diel's hydrocarbon and stereochemistry, structure determination and synthesis of cholesterol, testosterone, estrone and progesterone. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

UNIT- V**Prostaglandins**

Occurrence, nomenclature, classification. Synthesis of PGF_2 and PGF_{2a}

Plant Pigments

General methods of structure determination, synthesis of Apigenin, Quercetin Cyanidin, Hirsutin. Quercetin-3 glucoside, Diazein and cyanidine-7 glucoside. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

SEMESTER IV - THEORY PAPERPAPER -II**COURSE CODE – CHE4TH05**

**Course Credit = 04
(40 Lectures)**

UNIT- I

- i. Diastereoselective, π - facial addition of nucleophilic to chiral carbonyl compounds: Crams model and Felkin-Ann model
- ii. Stereoselective synthesis, Asymmetric synthesis: the principle of asymmetric synthesis. Achiral substrate modified by chiral auxiliary Prelog's rule

UNIT- II

Asymmetric synthesis by the use of

- i. Chiral substrate having prochiral unit
- ii. Chiral auxiliary
- iii. Chiral reagents

UNIT- III

Stereochemistry of some reaction

- i. Mc-Murry reaction.
- ii. Corey-Winter reaction.
- iii. Fragmentation reaction.
- iv. Wittig and related reaction.
- v. Julia olefination.

UNIT- IV

Stereochemistry of some reaction

- i. Conjugate addition with R_2CuLi
- ii. Mitsunobu reaction.
- iii. Stereochemistry of Pd catalyzed coupling reaction
- iv. Addition of Bromine and Peroxide on Cyclohexene.

UNIT- V

Vitamins : Structure determination including synthesis of
Thiamine (Vitamin B1)
Pyridoxine (Vitamin B6)
Biotin (Vitamin H)
Vitamin E

SEMESTER IV - THEORY PAPER

PAPER -III

Course Credit = 04
(40 Lectures)

COURSE CODE – CHE4TH06

Biomolecules

UNIT- I

Enzymes

Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Fisher's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetic. Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition, regulatory enzymes, Enzyme immobilization.

UNIT- II

Nucleic Acids

Secondary and Tertiary structure of DNA/RNA and stabilizing forces, polymorphic nature of DNA, Sequencing, solid phase synthesis; trimeric, phosphoramidite and phosphonate methods, Purification : HPLC and gel electrophoresis. Peptide nucleic acid (PNA).

UNIT- III

Lipids

Chemistry and synthesis of phospholipids and glycolipids of lipid aggregates, micelles, bi-layers and biological membrane

50
49

UNIT- IV

Antibiotics

Synthesis of penicillin G, chloramphenicol, cephalosporin, tetracycline and streptomycin

UNIT- V

Pyrethroids and Rotenones, Pheromones

Synthesis and reactions of Pyrethroids and Rotenones.

(For structure elucidation, emphasis is to be placed on the use of parameters wherever possible)

SPECIALISATION in PHYSICAL CHEMISTRY

SEMESTER IV - THEORY PAPER

PAPER -I

COURSE CODE – CHE4TH07

**Course Credit = 04
(40 Lectures)**

UNIT- I

Ideal and non-ideal solutions, Inter-connection between Raoult's law and Henry's Law, Determination of Partial Molar Properties, Thermodynamic functions of mixing of non-ideal solutions, Excess thermodynamic-functions.

UNIT- II

Gibbs-Duhem-Margules equation and its applications, Activity and activity coefficients, Activity coefficients from excess thermodynamic functions, The theory of Van Laar, Scatchard Hildebrand theory, Wilson model and Flory-Huggins theory.

UNIT- III

Concept of operators in quantum mechanics—operators for velocity, kinetic energy, momentum and angular momentum, Derivation of Heisenberg's uncertainty principle, Solution for Hydrogen atom, Born-Oppenheimer approximation, Valence bond theory and its application to homonuclear (Hydrogen) and heteronuclear (HCl) diatomics, LCAO-MO treatment of hydrogen molecule ion, Comparative study of MO and VB theory.

49
50

UNIT- IV

Huckel molecular orbital theory and its application to hybridization systems (ethylene, butadiene, allyls and benzene), Calculation of delocalization energy, Physical significance of charge density and bond order, Calculation of bond length, Pauling and Wheland's modification in HMO theory and its application to heteromolecules (pyrimidine), Perturbation methods in LCAO-MO theory, Extended Huckel molecular orbital theory and SCF-MO method,

UNIT- V

Stability and properties of colloids , Isotherms and surface area , Heterogeneous catalysis.

SEMESTER IV - THEORY PAPER

PAPER -II

Course Credit = 04
(40 Lectures)

COURSE CODE - CHE4TH08

UNIT- I

Classification of solids, Bonding in solids, covalent, metallic, ionic and molecular crystals, Lattice energy of crystals, Cohesive energy, Conduction in solids and superconductance, Electronic structures of solids, Free electron theory, Fermi-gas theory and band theory of solids, Metals, semi-conductors and insulators, Intrinsic extrinsic p-type and n-type semi-conductors,

UNIT- II

Vapour pressure, compressibility viscosity and sound velocity, Internal pressure and its determination, Significance of internal pressure, solubility parameter and cohesive-energy-density, Free volume of liquids and its determination, Application of free volume and its relation with energy and heat of vaporization.

UNIT- III

Partition function of a liquid, Equation of state in terms of partition function, Outline of the theory of liquid state: Simple cell theory (Eyring equation) and cell model theory of Lennard-Jones and Devonshire, Eyring's free volume theory of liquid viscosity, Effect of pressure on viscosity, Thermodynamic functions of ideal and non-ideal liquid mixtures, Partial molar properties of liquid mixtures, Determination of partial molar volume and partial molar enthalpy.

UNIT- IV

The triumph and limitations of Debye-Huckel theory of activity coefficients, Electrical potential and mean activity coefficient in the case of ionic clouds with finite sized ions, The ion size parameter and comparison of the finite-ion-size model with experiment, Asymmetry and electrophoretic effects, Stoke's law and Walden product, Debye-Huckel-Onsager equation, Conductance ratio and the Onsager slope, Verification of Debye-Huckel-Onsager equation, Conductivity of weak electrolytes and conductance in nonaqueous solvents, Modifications of Debye-Huckel-Onsager equation, Fuoss-Onsager and other equations, Wien and Debye-Falkenhagen effects.

UNIT- V

Viscosity of electrolyte solutions-Jones-Dole equation and significance of A and B coefficients, Ion association in an electrolyte solution, Formation of pairs, triplets etc, The probability of finding oppositely charged ions near each other, Bjerrum theory of ion association,

SEMESTER IV - THEORY PAPERPAPER -III**COURSE CODE – CHE4TH09****Course Credit = 04
(40 Lectures)**UNIT- I

Kinetics and mechanism of reactions on surface, Mechanism of surface reactions, Uni and bi-molecular surface reactions, Langmuir-Hinshelwood mechanism, Langmuir-Rideal mechanism, Inhibition of surface reactions, Absolute reaction rate theory of surface reactions.

UNIT- II

Comparison of homogeneous and heterogeneous reactions, Study of equilibrium constant and steady state treatment for Arrhenius and Vant Hoff's complexes, Influence of substituents on reaction rates (inductive and electromeric effects), Linear free energy relationship, Taft equation, compensation effect, Hammett acidity functions.

UNIT- III

- a) Oxidation of sugars by $K_3Fe(CN)_6$ and Cu^{+2} in alkaline medium,
- (b) Oxidation of organic molecules by $K_3Fe(CN)_6$ and Ce (IV),

UNIT- IV

Kinetic of initiation retardation, chain polymerization and ionic polymerization (anionic and cationic), Copolymerisation (with special reference to monomer reactivities ratios).

UNIT- V

Coordination polymerization, Degradation of polymers (oxidative, chemical and photolytic), An introduction to conducting polymers, Polyelectrolytesn oxidation of organic substrates by $K_3[Fe(CN)_6]$ and Ce(IV) in alkaline / acidic medium.

SPECIALISATION in ANALYTICAL CHEMISTRY

SEMESTER IV - THEORY PAPER

PAPER -I

COURSE CODE – CHE4TH10

**Course Credit = 04
(40 Lectures)**

Electroanalytical Methods

UNIT- I

SEMESTER IV - ELECTIVE PAPER

PAPER - II

COURSE CODE - CHE4TH14

**Course Credit = 04
(40 Lectures)**

Reagents and Reactions

Reagents in Organic Synthesis

UNIT: I

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible)

Complex metal hydrides - NaBH_4 , LiAlH_4 , DIBAL, diborane, diisoamylborane, tetrabutylborane, 9-BBN, isopinocampheyl and diisopinocampheylborane, catechoborane
Gilman's reagent
Lithium diisopropyl amide (LDA)

UNIT: II

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible):

Dicyclohexylcarbodiimide (DCC)
1, 3-Dithiane (Reactivity Umpolung)
Trimethylsilyl iodide
Tri n-butyltin hydride
DEAD

UNIT: III

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible):

DDQ
Hydrazine and phenylhydrazine
Nucleophilic heterocyclic carbenes (NHC)
Nitrogen, Sulphur and Phosphorus Ylides
Preparation and their synthetic applications.

UNIT: IV

Selective Organic name reaction and their Synthetic Application

Stork Enamine reaction
Ene Reaction
Barton Reaction
Hofmann-Löffler-Freytag Reaction
Shapiro Reaction

UNIT: V**Green Chemistry**

Introduction of green chemistry basic principles of green chemistry, organic synthesis using visible light, ionic liquid and PEGs.

Selective Organic name reaction and their Synthetic Application

Baylis-Hillman Reaction

Stetter Reaction

SEMESTER IV - ELECTIVE PAPER**PAPER – III****COURSE CODE – CHE4TH15****Course Credit = 04****(40 Lectures)**

SEMESTER IV - CHEMISTRY PRACTICALS

Inorganic Chemistry [in addition to CHE4TH01 , 02 , 03]

COURSE CODE – CHE4PR01

Course Credit = 02
(40 hrs)

1. Spectroscopic Determinations

- (a) Mn/Cr/V in steel Sample.
- (b) Ni/Mo/W/V/U/ by extractive spectrophotometric method.
- (c) Fluoride/ nitrite / Phosphate.
- (d) Iron – phenanthroline complex: Job's method.
- (e) Zirconium – Alizarin Red-S complexes: Mole-ratio method.
- (f) Copper-Ethylene diamine complexes: Slope-ratio method.
- (g) Iron-thiocyanate complex-Ionophoric method

2. Atomic Absorption Spectroscopy / *Flame photometry*

- (a) Estimation of metal ions.

3. Project Work

SEMESTER IV - CHEMISTRY PRACTICALS

Organic Chemistry [in addition to CHE4TH04 , 05 , 06]

COURSE CODE – CHE4PR02

Course Credit = 02
(40 hrs)

- (a) Estimation of $-\text{NO}_2$ group in organic compounds.
- (b) Isolation of casein from milk, piperine from black papper and nicotine from tobacco.
- (c) Applications of NMR spectroscopy (^1H & ^{13}C), UV, IR and Mass Spectroscopy in structure determination of organic and biologically important compounds
- (d) Project

SEMESTER IV - CHEMISTRY PRACTICALS

Physical Chemistry [in addition to CHE4TH07 , 08 , 09]

Course Credit = 02
(40 hrs)

COURSE CODE – CHE4PR03

1. Kinetics of Ir(III) catalysed oxidation of reducing sugars by sodium periodate in alkaline medium.
2. Kinetics of oxidation of reducing sugars by potassium iodate in alkaline medium using Ir(III) chloride as homogeneous catalyst.
3. Kinetics of Ru(III) catalysed oxidation of organic substrates by Ce(IV) sulphate in acidic medium .
4. Kinetics and mechanism of Ru(III) catalysed oxidation of reducing sugars by N- bromoacetamide in acidic medium .

SEMESTER IV - CHEMISTRY PRACTICALS

Analytical Chemistry [in addition to CHE4TH10 , 11 , 12]

COURSE CODE – CHE4PR04

1. Determination of calcium by Atomic Absorption spectrophotometry
2. Gas chromatographic analysis of a tertiary mixture
3. Enzymatic Determination of glucose
4. Determination of Cd^{2+} ion using polarography
5. Determination of Zn^{2+} ion using polarography
6. TGA
7. Least Square fitting
8. Composition of two sets of results of significance by
(i) student's t-test (ii) F-test
9. Project Experiment