CO-PO attainment
in
Outcome Based Education
Honours Programme
in
Outcome Based Education

Department of Chemistry

Government General Degree College, Kalna-I

Program Outcome (PO)

- **PO1: Disciplinary knowledge**
- **PO2: Communication Skills**
- **PO3: Critical thinking**
- **PO4 : Problem solving**
- **PO5: Self-directed learning**
- **PO6: Research-related skills**
- **PO7: Scientific reasoning**
- **PO8: Information/digital literacy**
- **PO9: Lifelong learning**

Program Specific Outcome (PSO): UG Chemistrty

- **PSO1: Foundation for Theoretical Concepts of Chemistry: To know the fundamentals, principles and theoretical methodologies to explain chemistry around us.**
- **PSO2: Foundation for Experimental/Numerical tools of Chemistry: The ability to implement/visualize the theoretical knowledge through laboratory based experimental /numerical techniques.**
- **PSO3: Foundation for possible further developments: Inspire and boost interest to realize global issues and to create foundation for advanced studies, research and development in Chemistry.**

Course Content

Semester: I **Course name: Organic Chemistry-I (Theo): Basics of Organic Chemistry**
Course Code: CC-I
(Credits: Theory-04, Practicals-02)

Semester-I
Hons. Core Course
Code: CC-1
Course Title: Organic Chemistry-I (Theo): Basics of Organic Chemistry
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Bonding and Physical Properties:

1. Valence Bond Theory: Concept of hybridisation, shapes of molecules, resonance (including hyperconjugation); calculation of formal charges and double bond equivalent (DBE); orbital pictures of bonding (sp3, sp2, sp: C-C, C-N & C-O systems and s-cis and s-trans geometry for suitable cases). 4 classes

2. Electronic displacements: inductive effect, field effect, mesomeric effect, resonance energy; bond polarization and bond polarizability; electromeric effect; steric effect, steric inhibition of resonance. 4 classes

3. MO theory: qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; basic idea about Frontier MOs (FMO); concept of HOMO, LUMO and SOMO; interpretation of chemical reactivity in terms of FMO interactions; sketch and energy levels of π MOs of i) acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems) ii) cyclic p orbital system (neutral systems: [4], [6]-annulenes; charged systems: 3-,4-,5-membered ring systems); Hückel's rules for aromaticity up to [10]-annulene (including mononuclear heterocyclic compounds up to 6-membered ring); concept of antiaromaticity and homoaromaticity; non-aromatic molecules; Frost diagram; elementary idea about α and β; measurement of delocalization energies in terms of β for buta-1,3-diene, cyclobutadiene, hexa-1,3,5-triene and benzene. 10 classes

4. Physical properties: influence of hybridization on bond properties: bond dissociation energy (BDE) and bond energy; bond distances, bond angles; concept of bond angle strain (Baeyer's strain theory); melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments; relative stabilities of isomeric hydrocarbons in terms of heat of hydrogenation, heat of combustion and heat of formation. 6 classes

General Treatment of Reaction Mechanism I

1. Mechanistic classification: ionic, radical and pericyclic (definition and example); reaction type: addition, elimination and substitution reactions (definition and example); nature of bond cleavage and bond formation: homolytic and heterolytic bond fission, homogenic and heterogenic bond formation; curly arrow rules in representation of mechanistic steps; reagent type: electrophiles and nucleophiles (elementary idea); electrophilicity and nucleophilicity in terms of FMO approach. 8 classes

2. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes: generation and stability, structure using orbital picture and electrophilic/nucleophilic behavior of reactive intermediates (elementary idea). 4 classes

Stereochemistry-I

1. Bonding geometries of carbon compounds and representation of molecules: Tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying-wedge and Newman projection formulae and their inter translations. 4 classes
2. Concept of chirality and symmetyry; symmetry elements and point groups (Cv, Cnv, Cnh, Cn, Dh, Dnh, Dnd, Dn, Sn (Cs, Ci); molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of epimers; concept of stereogenicity, chirotopicity and pseudoasymmetry; chiral centres and number of stereoisomerism: systems involving 1/2/3-chiral centre(s) (AA, AB, ABA and ABC types). 10 classes

3. Relative and absolute configuration: D/L and R/S descriptors; erythro/threo and meso nomenclature of compounds; syn/anti nomenclatures for aldols; E/Z descriptors for C=C, conjugated diene, triene, C=N and N=N systems; combination of R/S- and E/Z-isomerisms. 4 classes

4. Optical activity of chiral compounds: optical rotation, specific rotation and molar rotation; racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates); resolution of acids, bases and alcohols via diastereomeric salt formation; optical purity and enantiomeric excess. 6 classes

Contd……

PRACTICALS:

- *Separation Based upon solubility*, by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc., of components of a binary solid mixture.

- *Purification* of any one of the separated components by crystallization and determination of its melting point. The composition of the mixture may be of the following types: Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p-Aminobenzoic acid; p-Nitrotolune/p-Anisidine.

- *Determination of boiling point* of common organic liquid compounds e.g., ethanol, cyclohexane, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide. [Boiling point of the chosen organic compounds should preferably be less than 160 °C].

- *Identification of a Pure Organic Compound by Chemical Test(s)*
  Solid compounds: oxalic acid, succinic acid, resorcinol, urea, glucose and salicylic acid.
  Liquid Compounds: acetic acid, ethyl alcohol, acetone, aniline and nitrobenzene.

Course Outcome (CO)	Paper: CC-I

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Understand** bonding and orbital pictures of different organic molecules.	**L2:** Understanding	1, 2, 4, 5, 7,8, 9	**1, 2, 3**
2	**Define** the physical properties of molecules such as hybridization, bond dissociation energy, bond angle etc.	**L1:** Remembering	1, 2, 3, 5, 6, 8, 9	**1, 2, 3**
3	**Elementary idea** about classification of reaction mechanism.	**L2:** Understanding	1,2, 3, 4, 7, 8,9	**1, 2, 3**
4	**Identify** reactive intermediates.	**L4:** Analyzing	1, 3, 4, 5, 6,7, 8,9	**1, 2, 3**
5	**Predict** three dimensional geometries of molecules and point groups therein.	**L3:** Applying	1, 3, 4, 5,6, 7, 8,9	**1, 2, 3**
Practical				
1	**Understand** bonding and orbital pictures of different organic molecules.	**L2:** Understanding	1, 2, 4, 5, 6,7,8, 9	**1, 2, 3**
3	**Determination** of boiling point of common organic liquid compounds	**L5:** Evaluating	1, 2, 3, 4, 5, 6, 7, 8	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	-	3	2	-	2	3	3	2	2	2
	2	2	3	3	-	3	3	-	3	3	2	2	3
	3	3	3	3	2	-	-	3	2	3	3	3	2
	4	3	2	3	3	3	3	2	3	2	2	3	3
	5	3	3	3	3	3	2	3	3	3	2	3	3
Practical	1	2	3	-	2	3	3	3	2	2	3	3	3
	2	3	3	3	3	3	3	3	3	3	3	3	3
	Average	2.7	2.8	2.1	2.3	2.4	2.0	2.3	2.7	2.7	2.4	2.7	2.7

Course Content

Semester: I | **Course Code: CC-II**
Course name: Physical Chemistry-I (Theo) | **(Credits: Theory-04, Practicals-02)**

CC-II: F.M.=75 (Theory-40, Practical–20, Internal Assessment–15)
Theory:
Kinetic Theory and Gaseous state

1. Kinetic Theory of gases: Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion. 4 classes
2. Maxwell's distribution of speed and energy: Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases. 6 classes
3. Real gas and virial equation: Deviation of gases from ideal behaviour; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour, other equations of state (Berthelot, Dietrici); Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; virial equation of state; van der Waals equation expressed in virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea).

Chemical Thermodynamics

1. Zeroth and 1st law of Thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy and statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence. 6 classes

2. Thermochemistry: Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions; Adiabatic flame temperature; explosion temperature. 6 classes
3. Second Law: Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of §dQ/T and Clausius inequality; Entropy change of systems and surroundings for various processes and transformations; Entropy and unavailable work; Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium.
8 classes
4. Thermodynamic relations: Maxwell's relations; Gibbs- Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas; General heat capacity relations.

Chemical kinetics

1. Rate law, order and molecularity: Introduction of rate law, Extent of reaction; rate constants, order; Forms of rates of First, second and nth order reactions; Pseudo first order reactions (example using acid catalysed hydrolysis of methyl acetate); Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions (with explanation of kinetic and thermodynamic control of products; all steps first order). 6 classes
2. Role of Temperature and theories of reaction rate: Temperature dependence of rate constant; Arrhenius equation, energy of activation; Rate-determining step and steady-state approximation – explanation with suitable examples; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment). 4 classes
3. Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turnover number.

4. Autocatalysis; periodic reactions 4 classes

List of Practicals

1. Determination of pH of unknown solution (buffer), by color matching method;
2. Determination of the reaction rate constant of hydrolysis of ethylacetate in the presence of an equal quantity of sodium hydroxide;
3. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate;
4. Study of kinetics of decomposition of H_2O_2 by KI;
5. Determination of solubility product of PbI_2 by titremetric method.

Course Outcome (CO)	Paper: CC-II

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Generalize** the mechanistic approaches about the different types of interactions in the gaseous molecules.	**L2:** Understanding	1,2,3,5,7,8,9	**1, 2, 3**
2	**Predict** the differences in between real gases and ideal gases in terms of the attraction and repulsion factors	**L2:** Understanding	1,2,3,5,7,8,9	**1, 2, 3**
3	**Construct** the Carnot's cycles of ideal gas or real gas with respect to the various thermodynamical parameters.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7, 8,9	**1, 2, 3**
4	**Describe** the detailed idea about the catalysis.	**L1:** Remembering	1, 2, 5, 7, 8,9	**1, 2, 3**
5	**Create** the integrated form of the rate equation of various order of the reaction.	**L6:** Creating	1,2, 3, 4, 6,5,6, 7, 8,9	**1, 2, 3**
Practical				
1	**Determine** pH and rate constant of a reaction.	**L5:** Evaluating	1, 2, 3, 4, 6,7, 8, 9	**1, 2, 3**
2	**Analyze** the kinetics of acid-catalysed hydrolysis of ester.	**L4:** Analyzing	1, 2, 3, 4, 5,6, 7, 8	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

CO		Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	2	-	3	-	3	3	2	3	2	3
	2	3	3	2	-	2	-	2	-	3	2	2	3
	3	3	2	2	3	2	3	2	3	3	2	2	2
	4	2	2	-	3	3	3	3	2	2	3	3	2
	5	3	2	3	3	3	3	3	2	3	3	3	2
Practical	1	2	3	3	3	2	2	3	3	2	3	3	3
	2	3	3	3	3	2	3	3	3	3	3	3	3
	Average	2.6	2.6	2.1	2.1	2.4	2.0	2.7	2.3	2.6	2.7	2.6	2.6

Course Content

Semester: II **Course name: Inorganic Chemistry-I (Theo) Course Code: CC-III**
(Credits: Theory-04, Practicals-02)

Code: CC-3

Course Title: Inorganic Chemistry-I (Theo)

(Credits: Theory-04, Practical-02)

F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Extra nuclear Structure of atom

Bohr's theory, its limitations and atomic spectrum of hydrogen atom; Sommerfeld's Theory. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rules and multiplicity, Exchange energy, Aufbau principle and its limitations, Ground state Term symbols of atoms and ions for atomic number upto 30. ***16 classes***

Chemical periodicity

Modern IUPAC Periodic table, Effective nuclear charge, screening effects and penetration, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, lanthanide contraction. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) and factors influencing these properties, group electronegativities. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements. Seconary periodicity, Relativistic Effect, Inert pair effect. ***12 classes***

Acid-Base reactions

Acid-Base concept: Arrhenius concept, theory of solvent system (in H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling's rules. Lux-Flood concept, Lewis concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Thermodynamic acidity parameters, Drago-Wayland equation. Superacids, Gas phase acidity and proton affinity; HSAB principle. Acid-base equilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer. Acid-base neutralisation curves; indicator, choice of indicators. ***12 classes***

Redox Reactions and precipitation reactions

Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples); Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides.

20 classes

List of Practicals:

Oxidation-Reduction Titrimetric

1. Estimation of Fe(II) using standardized $KMnO_4$ solution
2. Estimation of oxalic acid and sodium oxalate in a given mixture
3. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution
4. Estimation of Fe(III) and Mn(II) in a mixture using standardized $KMnO_4$ solution
5. Estimation of Fe(III) and Cu(II) in a mixture using $K_2Cr_2O_7$
6. Estimation of Fe(III) and Cr(III) in a mixture using $K_2Cr_2O_7$

Course Outcome (CO)	Paper: CC-III

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Understand** the extra nuclear structure of atom and get a basic idea about Quantum Chemistry and its application.	**L2:** Understanding	1, 2, 4, 5, 8, 9	**1, 2, 3**
2	**Explain** the chemical periodicity in terms of physical and chemical properties of the elements along a group or period, factors influences those properties, relativistic effects and inertpair effect.	**L2:** Understanding	1, 2, 4, 5,7, 8, 9	**1, 2, 3**
3	**Describe** the different types of acids, their definitions and also gives a clear concept about pH, buffer, and indicator.	**L2:** Understanding	1, 2, 3,4, 5,6, 8, 9	**1, 2, 3**
4	**Predict** the acid-base neutralization curves and choice of indicators**.**	**L3:** Applying	1, 2,3, 4, 6,5, 7, 8,9	**1, 2, 3**
5	**Illustrate** the redox reactions – oxidation and reduction reactions, oxidation number, competitive electron transfer reaction, electrode process.	**L4:** Analyzing	1,2, 3, 4, 5,6, 7, 8,9	**1, 2, 3**
Practical				
1	**Estimation** of Fe(II), Fe(III) and Mn(II) in a mixture using permanganometry.	**L5:** Evaluating	1, 2, 3, 4, 5, 6,8, 9	**1, 2, 3**
2	**Estimation** of oxalic acid and sodium oxalate using permanganometry.	**L5:** Evaluating	1, 2, 3, 4, 5, 6,8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	-	2	3	-	-	3	3	3	3	3
	2	3	2	-	2	2	-	3	3	2	3	3	3
	3	2	2	3	3	2	2	-	3	2	2	3	3
	4	3	3	3	3	2	3	2	2	3	3	3	3
	5	2	2	3	2	2	3	3	2	3	2	2	2
Practical	1	3	3	3	3	3	3	3	2	3	3	3	2
	2	3	3	3	3	3	3	3	3	3	3	3	2
	Average	2.7	2.6	2.2	2.6	2.4	2.0	2.0	2.6	2.7	2.7	2.9	2.8

Course Content

Semester: II

Course name : Organic Chemistry-II (Theo)

Course Code: CC-IV

(Credits: Theory-04, Practicals-02)

Course Title: Organic Chemistry-II (Theo)

(Credits: Theory-04, Practical-02)

F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Stereochemistry II

1. Chirality arising out of stereoaxis: stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, spiro compounds, alkylidenecycloalkanes and biphenyls; related configurational descriptors (Ra/Sa and P/M); atropisomerism; racemisation of chiral biphenyls; buttressing effect. 6 classes
2. Concept of prostereoisomerism: prostereogenic centre; concept of (pro)n-chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-r and pro-s descriptors of ligands on propseudoasymmetric centre. 4 classes
3. Conformation: conformational nomenclature: eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; P/M descriptors; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, n-butane. 8 classes
4. 2-methylbutane and 2,3-dimethylbutane; haloalkane, 1,2-dihaloalkanes and 1,2-diols (up to four carbons); 1,2-halohydrin; conformation of conjugated systems (s-cis and s-trans). 4 classes

General Treatment of Reaction Mechanism II

1. Reaction thermodynamics: free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions. 4 classes
2. Concept of organic acids and bases: effect of structure, substituent and solvent on acidity and basicity; proton sponge; gas-phase acidity and basicity; comparison between nucleophlicity and basicity; HSAB principle; application of thermodynamic principles in acid-base equilibria. 4 classes
3. Tautomerism: prototropy (keto-enol, amido-imidol, nitroso-oximino, diazo-amino and enamine-imine systems); and ring-chain tautomerism; composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism; application of thermodynamic principles in tautomeric equilibria. 6 classes
4. Reaction kinetics: rate constant and free energy of activation; concept of order and molecularity; free energy profiles for one-step, two-step and three-step reactions; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and secondary kinetic isotopic effect (kH /kD); principle of microscopic reversibility. 4 classes

Substitution and Elimination Reactions

1. Free-radical substitution reaction: halogentaion of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate. 4 classes
2. Nucleophilic substitution reactions: substitution at sp3 centre: mechanisms (with evidence), relative rates & stereochemical features: SN1, SN2, SN2', SN1' (allylic rearrangement) and SNi; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP; role of crown ethers and phase transfer catalysts; [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides]. 10 classes

3. Elimination reactions: E1, E2, E1cB and Ei (pyrolytic syn eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination. 6 classes

List of Practicals:

Organic Preparations

A. The following reactions are to be performed, noting the yield of the crude product:

1. Nitration of acetanilide
2. Condensation reactions: Synthesis of 7-hydroxy-4-methylcoumarin
3. Hydrolysis of amides/imides/esters
4. Acetylation of phenols/aromatic amines (using Zn-dust/Acetic Acid)
5. Benzoylation of phenols/aromatic amines
6. Side chain oxidation of toluene and p-nitrotoluene
7. Diazo coupling reactions of aromatic amines
8. Bromination of acetanilide using green approach (Bromate-Bromide method)
9. Green 'multi-component-coupling' reaction: Synthesis of dihydropyrimidone
10. Selective reduction of m-dinitrobenzene to m-nitroaniline Students must also calculate percentage yield, based upon isolated yield (crude) and theoretical yield.

B. Purification of the crude product is to be made by crystallisation from water/alcohol, crystallization after charcoal treatment, or sublimation, whichever is applicable.

C. Melting point of the purified product is to be noted

Course Outcome (CO) Paper: CC-IV

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Define** stereoisomerism and chirality arising out of stereo axis.	**L1:** Remembering	1, 2, 4, 5, 8,9	**1, 2, 3**
2	**Analysis** of conformation across the C-C and C=C bond.	**L4:** Analyzing	1, 2, 3, 4, 5,6, 7, 8, 9	**1, 2, 3**
3	**Demonstrate** of reaction thermodynamics and kinetics**.**	**L3:** Applying	1, 2,3, 4, 6, 7, 8, 9	**1, 2, 3**
4	**Measure** of acid and base strength of organic molecules	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
5	**Explain** tautomeric behaviour of different organic functionalities.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
Practical				
1	**Design** reactions using green approach.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7, 8, 9	**1,2,3**
2	**Estimation** of melting points	**L4:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

CO		Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	-	3	3	-	-	3	3	2	2	3
	2	3	3	2	2	2	3	3	2	3	2	2	2
	3	2	2	3	3	3	3	3	3	2	3	3	3
	4	3	3	3	3	3	3	3	2	3	3	3	3
	5	3	3	2	2	-	3	-	3	2	2	3	2
Practical	1	3	3	3	3	2	2	3	3	3	3	3	3
	2	3	2	3	3	2	2	3	3	3	3	3	3
	Average	2.9	2.7	2.3	2.7	2.1	2.0	2.3	2.7	2.7	2.6	2.7	2.7

Course Content

Semester: III **Course name: Physical Chemistry-II (Theo)**
Course Code: CC-V
(Credits: Theory-04, Practicals-02)

Course Title: Physical Chemistry-II (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Transport Processes:

1. Fick's law: Flux, force, phenomenological coefficients & their inter-relationship (general form), different examples of transport properties.
2. Viscosity: General features of fluid flow (streamline flow and turbulent flow); Newton'sequation, viscosity coefficient; Poiseuille's equation; principle of determination of viscosity coefficient of liquids by falling sphere method; Temperature variation of viscosity of liquids and comparison with that of gases.

3. Conductance and transport number: Ion conductance; Conductance and measurement of conductance, cell constant, specific conductanceand molar conductance; Variation of specificand equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law ofindependent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Debye-Hückel theory of Ion atmosphere(qualitative)-asymmetric effect, relaxation effect and electrophoretic effect; Ostwald's dilutionlaw; Ionic mobility; Application of conductance measurement (determination of solubilityproduct and ionic product of water); Conductometric titrations.
4. Transport number, Principles of Hittorf's, and Moving-boundary method; Wien effect, Debye-Falkenhagen effect, Walden's rule.

Application of Thermodynamics – I

1. Partial properties and Chemical potential: Chemical potential and activity, partial molarquantities, relation between Chemical potential and Gibb's free energy and other thermodynamic state functions; variation of Chemical potential (μ) with temperature and pressure; Gibbs-Duhem equation; fugacity and fugacity coefficient; Variation of thermodynamic functions for systems with variable composition, Equations of states for these systems, Change in G, S, H and Vduring mixing for binary solutions.
2. Chemical Equilibrium: Thermodynamic conditions for equilibrium, degree of advancement. van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change;Definitions of K_P, K_C and K_X; van't Hoff's reaction isobar and isochore from different standard states: Shifting of equilibrium due to change in external parameters e.g. temperature andpressure; variation of equilibrium constant with addition to inert gas; Le Ch atelier's principle andits derivation.
3. Nernst's distribution law; Application- (finding out K_{eq} using Nernst distribution law for KI+I2 = KI3and dimerization of benzene.
4. Chemical potential and other properties of ideal substances- pure and mixtures:

a) Pure ideal gas-its Chemical potential and other thermodynamic functions and their changes during a process; Thermodynamic parameters of mixing; Chemical potential of an ideal gas in anideal gas mixture; Concept of standard states and choice of standard states of ideal gases.

b) Condensed Phase – Chemical potential of pure solid and pure liquids, Ideal solution – Definition, Raoult's law; Mixing properties of ideal solutions, chemical potential of a component in an ideal solution; Choice of standard states of solids and liquids.

Foundation of Quantum Mechanics

1. Beginning of Quantum Mechanics: Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (Without proof).
2. Wave function: Schrödinger time-independent equation; nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function.
3. Concept of Operators: Elementary concepts of operators, eigenfunctions and eigenvalues.Linear operators; Commutation of operators, commutator, and uncertainty relation; Expectation value; Hermitian operator; Postulates of Quantum Mechanics.
4. Particle in a box: Setting up of Schrödinger equation for one-dimensional box and its solution. Comparison with free particle eigenfunctions and eigenvalues. Properties of PB wave functions (Normalization, orthogonality, probability distribution); Expectation values of x, x^2, p_x and p_x^2 and their significance in relation to the uncertainty principle; Extension of the problem to two and three dimensions and the concept of degenerate energy levels.
5. Simple Harmonic Oscillator: setting up of the Schrödinger stationary equation, energy expression (without derivation), expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic features

List of Practicals:

1. Study of viscosity of unknown liquid (glycerol, sugar) with respect to water.
2. Determination of partition coefficient for the distribution of I_2 between water and CCl_4.
3. Determination of K_{eq} for $KI + I_2 \Leftrightarrow KI_3$, using partition coefficient between water and CCl_4.
4. Conductometric titration of an acid (strong, weak/ monobasic, dibasic) against strong base.
5. Study of saponification reaction conductometrically.
6. Verification of Ostwald's dilution law and determination of K_a of weak acid.

Course Outcome (CO)	Paper: CC-V

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**List** the various types of transport processes.	**L1:** Remembering	1, 2, 4, 5, 8,9	**1, 2, 3**
2	**Judge** the viscosity of different molecular liquids according to their chemical identities.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
3	**Evaluate** the various conductance terms of the specific electrolytic solution.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
4	**Compute** the K_{eq} value using Nernst Distribution Law	**L3:** Applying	1, 2,3, 4, 6, 7, 8, 9	**1, 2, 3**
5	**Differentiate** between Classical Mechanics and Quantum Mechanics.	**L4:** Analyze	1, 2, 3, 4, 5,6, 7, 8, 9	**1, 2, 3**
Practical				
1	**Determine** partition coefficient & viscosity of unknown liquid.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
2	**Apply** Ostwald's dilution law for determination of K_a of weak acid.	**L3:** Applying	1, 2,3, 4, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	2	-	3	2	-	-	3	2	3	2	2
	2	2	2	3	2	3	3	3	2	3	3	2	3
	3	3	2	2	3	2	2	2	3	2	2	2	2
	4	2	2	3	2	-	3	3	3	3	3	2	3
	5	3	2	3	3	3	2	3	3	3	3	2	3
Practical	1	3	3	3	3	3	3	3	3	2	3	3	3
	2	3	3	3	3	3	3	3	2	3	3	3	3
	Average	2.7	2.3	2.4	2.7	2.3	2.7	2.4	2.7	2.6	2.9	2.3	2.7

Course Content

Semester: III

Course name: Inorganic Chemistry-II (Theo)
Course Code: CC-VI
(Credits: Theory-04, Practicals-02)

Semester-III
Hons. Core Course
Code: CC-6
Course Title: Inorganic Chemistry-II (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Chemical Bonding-I

1. Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Solubility energetics of dissolution process.
2. Covalent bond: Polarizing power and polarizability, ionic potential, Fazan's rules. Lewis structures, formal charge. Valence Bond Theory. The hydrogen molecule (Heitler-London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, Dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding (σ and π bond approach).

20 classes

Chemical Bonding-II

1. Molecular orbital concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO)) (elementary pictorial approach): sigma and pi-bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing, MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO^+, CN^-, HF, BeH_2, CO_2 and H_2O. Bond properties: bond orders, bond lengths.
2. Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids – stoichiometric and non-stoichiometric.
3. Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Intermolecular forces: Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points. 30 classes

Radioactivity

1. Nuclear stability and nuclear binding energy. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers.
2. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Separation and uses of isotopes.
3. Radio chemical methods: principles of determination of age of rocks and minerals, radiocarbon dating hazards of radiation and safety measures. 10 Classes

List of Practicals:

Iodo/Iodimetric Titrations

1. Estimation of Cu(II).
2. Estimation of Vitamin C.
3. Estimation of arsenite by iodimetric method.
4. Estimation of Cu in brass.
5. Estimation of Cr and Mn in Steel.

Course Outcome (CO)	Paper: CC-VI

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Explain** the Ionic bond and Covalent bond**,** laws, rules and equations for formation of chemical bonds, solubility, hybridization and dipole moment of molecules.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
2	**Predict** the shapes of molecules and ions containing lone pairs and bond pairs using VSEPR theory and Bent's rule.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
3	**Understand** the concept about MOT (Molecular orbital theory), LCAO (Linear combination of atomic orbitals), Metallic bond and Weak Chemical Forces etc.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
4	**Apply** the MOT to evaluate the bond properties like bond orders and bond lengths.	**L3:** Applying	1, 2,3, 4,5, 6, 7, 8, 9	**1, 2, 3**
5	**Outline** the effects of weak chemical force on melting and boiling points.	**L4:** Analyzing	1, 2, 3, 4, 5,6, 7, 8, 9	**1, 2, 3**
Practical				
1	**Estimate** Cu (II), Arsenite (AsO_3^{3-}) and vitamin C using iodometric titrations.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
2	**Estimate** Cu in brass & Cr, Mn in Steel.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	3	2	-	2	-	3	3	2	3	3
	2	3	3	2	2	3	2	2	2	2	2	2	3
	3	2	2	3	3	-	3	-	3	3	3	3	3
	4	3	3	3	3	2	3	3	2	2	3	2	2
	5	2	2	2	2	3	3	3	2	2	3	2	2
Practical	1	3	3	3	3	3	3	3	3	3	3	3	3
	2	3	3	2	3	3	3	3	3	3	3	3	3
	Average	2.7	2.7	2.6	2.6	2.0	2.9	2.0	2.3	2.6	2.7	2.6	2.7

Program Outcome (PO) & Program Specific Outcome (PSO) heads the PO/PSO columns.

Course Content

Semester: III **Course name: Organic Chemistry-III (Theo) Course Code: CC-VII**
(Credits: Theory-04, Practicals-02)

Course Title: Organic Chemistry-III (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Chemistry of alkenes and alkynes

1. Addition to C=C: mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenations, iodolactonisation, hydrohalogenation, hydration, oxymercurationdemercuration, hydroboration-oxidation, epoxidation, syn and anti-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; electrophilic addition to diene (conjugated dienes and allene); radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; Birch reduction of benzenoid aromatics; interconversion of E- and Z-alkenes. 10 classes
2. Addition to C≡C (in comparison to C=C): mechanism, reactivity, regioselectivity (Markownikoff and anti-Markownikoff addition) and stereoselectivity; reactions: hydrogenation, halogenations, hydrohalogenation, hydration, oxymercuration-demercuration, hydroborationoxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity. 6 classes

Aromatic Substitution

1. Electrophilic aromatic substitution: mechanisms and evidences in favour of it; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbon electrophiles (reactions: chloromethylation, Gatterman-Koch, Gatterman, HoubenHoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); Ipso substitituion. 6 classes
2. Nucleophilic aromatic substitution: addition-elimination mechanism and evidences in favour of it; cine substitution (benzyne mechanism), structure of benzyne and unimolecular mechanism. 4 classes

Carbonyl and Related Compounds

1. Addition to C=O: structure, reactivity and preparation of carbonyl compounds; mechanism (with evidence), reactivity, equilibrium and kinetic control; Burgi-Dunitz trajectory in nucleophilic additions; formation of hydrates, cyano hydrins and bisulphite adduct; nucleophilic addition-elimination reactions with alcohols, thiols and nitrogen- based nucleophiles; reactions: benzoin condensation, Cannizzaro and Tischenko reactions, reactions with ylides: Wittig reaction; oxidations and reductions: Clemmensen, Wolff-Kishner, LiAlH4, NaBH4, MPV, Oppenauer, Bouveault-Blanc, acyloin condensation; oxidation of alcohols with PDC and PCC; periodic acid and lead tetraacetate oxidation of 1,2-diols. 10 classes
2. Exploitation of acidity of α-H of C=O: formation of enols and enolates; kinetic and thermodynamic enolates; reactions (mechanism with evidence): halogenation of carbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (H. V. Z.) reaction, nitrosation, SeO2 (Riley) oxidation; condensations (mechanism with evidence): Aldol, Tollens', Knoevenagel, Claisen-Schmidt, Claisen ester including Dieckmann, Stobbe; Mannich reaction, Perkin reaction, Favorskii rearrangement; alkylation of active methylene compounds; preparation and synthetic applications of diethyl malonate and ethyl acetoacetate; specific enol equivalents (lithium enolates, enamines) in connection with alkylation, acylation and aldol type reaction. 8 classes
3. Aldol, Friedel-Crafts, Michael, Knoevenagel, Cannizzaro, Benzoin condensation and Dieckmann condensation by greener approach. 2 classes
4. Nucleophilic addition to α,β-unsaturated carbonyl system: general principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction), Robinson annulation. 2 classes
5. Substitution at sp2 carbon (C=O system): mechanism (with evidence): BAC2, AAC2, AAC1, AAL1 (in connection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison). 6 classes

Organometallics

Grignard reagent; Organolithiums; Gilman cuprates: preparation and reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; substitution on COX; conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behavior of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; concept of umpolung and base-nucleophile dichotomy in case of organometallic reagents. 6 classes

List of Practicals:

Qualitative Analysis of Single Solid Organic Compounds

1. Detection of special elements (N, S, Cl, Br) by Lassaigne's test
2. Solubility and classification (solvents: H_2O, 5% HCl, 5% NaOH and 5% $NaHCO_3$)
3. Detection of the following functional groups by systematic chemical tests:

aromatic amino ($-NH_2$), aromatic nitro ($-NO_2$), amido ($-CONH_2$, including imide), phenolic – OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O); only one test for each functional group is to be reported.

4. Melting point of the given compound
5. Preparation of one derivative of the given sample each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups with relevant derivatisation in known and unknown (at least six) organic compounds.

Course Outcome (CO) **Paper: CC-VII**

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Understand** chemical transformations of alkenes with various reagents and reaction conditions.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
2	**Illustrate** mechanism, reactivity, selectivity and reactions of alkynes.	**L4:** Analyzing	1, 2, 3, 4, 5,6, 7, 8, 9	**1, 2, 3**
3	**Predict** electrophilic aromatic substitution reactions and mechanistic evidences therein.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
4	**Identify** aromatic nucleophilic substitution reactions and its application towards molecular complexity.	**L4:** Analyzing	1, 2, 3, 4, 5,6, 7, 8, 9	**1, 2, 3**
5	**Use** various named reactions of carbonyl compounds and their utilization into routine synthesis of valuable compounds.	**L3:** Applying	1, 2,3, 4,5, 6, 7, 8, 9	**1, 2, 3**
Practical				
1	**Estimate** of the functional groups by systematic chemical tests & melting point of the given compound.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
2	**Prepare** derivatives of the given sample.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	2	2	-	3	-	3	3	2	2	3
	2	3	3	2	2	2	2	2	2	2	2	2	3
	3	2	2	3	3	3	3	3	3	3	3	3	2
	4	3	3	3	2	3	3	3	2	2	3	3	3
	5	3	2	3	3	2	2	2	3	3	3	3	2
Practical	1	3	3	3	2	3	3	3	3	2	3	3	3
	2	3	3	3	3	3	3	3	3	3	3	2	3
	Average	2.9	2.7	2.7	2.6	2.3	2.7	2.3	2.7	2.6	2.7	2.6	2.7

Program Outcome (PO) & Program Specific Outcome (PSO)

Course Content

Semester: III
Course name: IT skill in Chemistry

Course Code: SEC-1
(Credits: Theory-02)

Course Title: IT skill in Chemistry
(Credits: 02)
F.M. = 50 (Theory-40, Internal Assesment-10)

Theory: 30 Lectures

Mathematics

1. Fundamentals: mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, interconversion of units, constants and variables, equation of a straight line, plotting graphs.
2. Uncertainty in measurement: Displaying uncertainties, types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors. Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression).
3. Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms).Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary-bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).
4. Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
5. Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

Computer Programming

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis. BASIC programs for curve fitting, numerical differentiation and integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method). Handling numeric data Spreadsheet software (Excel), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs. Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs using a spreadsheet (Planck's distribution law, radial distribution curves for hydrogenic orbitals, gas kinetic theory- Maxwell-Boltzmann distribution curves as function of temperature and molecular weight), spectral data, pressure-volume curves of van der Waals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solution of equations.

Course Outcome (CO) Paper: SEC-1

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Formulate** fundamental mathematical functions and algebraic operations to measure data.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**
2	**Design** differential calculus and numerical integration for real measurements.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**
3	**Explain** basics of Computer Programming such as constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions etc.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
4	**Design** spreadsheet (Excel), entering and formatting information, basic functions and formulae, creating charts, tables and graphs. Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs for handling numeric data.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3
1	3	3	2	3	2	3	3	3	2	3	3	2
2	3	3	2	2	3	3	2	2	2	3	3	3
3	2	2	3	3	-	2	-	3	3	2	2	3
4	3	3	3	2	3	3	3	2	3	2	3	3
Average	2.8	2.8	2.5	2.0	2.0	2.8	2.0	2.5	2.5	2.5	2.8	2.8

Course Content

Semester: IV **Course name: Physical Chemistry-III (Theo) Course Code: CC-VIII (Credits: Theory-04, Practicals-02)**

Course Title: Physical Chemistry-III (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Application of Thermodynamics – II

1. Colligative properties: Vapour pressure of solution; Ideal solutions, ideally diluted solutions and colligative properties; Raoult's law; Thermodynamic derivation using chemical potential to derive relations between the four colligative properties, i.e., (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) Osmotic pressure. Applications in calculating molar masses of solute; Abnormal colligative properties for dissociatedand associated solutes in solution.
2. Phase rule: Definitions of phase, component and degrees of freedom; Phase rule and its derivations; Phase diagram for water, CO2, Sulphur
3. First order phase transition and Clapeyron equation; Clausius-Clapeyron equation – derivation and use; Liquid vapour equilibrium for two component systems.
4. Three component systems, water-chloroform-acetic acid system, triangular plots
5. Binary solutions: Ideal solution at fixed temperature and pressure; Principle of fractional distillation; Duhem-Margules equation; Henry's law; Konowaloff's rule; Positive and negative deviations from ideal behaviour; Azeotropic solution; Liquid-liquid phase diagram using phenol water system; Solid-liquid phase diagram; Eutectic mixture.

Electrical Properties of molecules

1. Ionic equilibria: Chemical potential of an ion in solution; Activity and activity coefficients of ions in solution; Debye-Hückel limiting law-brief qualitative description of the postulates involved, qualitative idea of the model, the equation (without derivation) for ion-ion atmosphere interaction potential. Calculation of activity coefficient for electrolytes using Debye-Hückel limiting law; Derivation of mean ionic activity coefficient from the expression of ion-atmosphere interaction potential; Applications of the equation and its limitations.
2. Electromotive Force: Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry; Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMFmeasurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii)equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes.
3. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Quantum Chemistry

1. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component; Rigid rotor model of diatomic molecule; Schrödinger equation, transformation to spherical polar coordinates; Separation of variables. Spherical harmonics; Discussion of solution.
2. Qualitative treatment of hydrogen atom and hydrogen-like ions: Setting up of Schrödinger equation in spherical polar coordinates, radial part,quantization of energy (only final energy expression); Average and most probable distances of electron from nucleus; Setting up of Schrödinger equation for many-electron atoms (He, Li).
3. LCAO and HF-SCF: Covalent bonding, valence bond and molecular orbital approaches,LCAO-MO treatment of H2+; Bonding and antibonding orbitals; Qualitative extension to H2; Comparison of LCAO-MO and VB treatments of H2 and their limitations.

List of Practicals:

1. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator).
2. Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$ solution.
3. Determination of K_{sp} for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution.
4. Effect of ionic strength on the rate of Persulphate – Iodide reaction.
5. Study of phenol-water phase diagram

Course Outcome (CO)	Paper: CC-VIII

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Construct** the LCAO model for the critical chemical compounds.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**
2	**List** the ideal solutions and real solutions according to Roult's Law.	**L1:** Remembering	1, 2, 4, 5, 8,9	**1, 2, 3**
3	**Design** the overall cell diagram of various chemical reactions.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**
4	**Measure** the Equilibrium constant using the value of cell potential.	**L5:** Evaluating	1, 2, 3, 4,5, 6, 7,8,9	**1, 2, 3**
5	**Formulate** the Hamiltonian operator for the mono/multi-electronic chemical systems.	**L6:** Creating	1, 2, 3, 4, 5, 6, 7,8, 9	**1, 2, 3**
Practical				
1	**Determine** solubility and solubility product of sparingly soluble salts.	**L4:** Analyzing	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Evaluate** potentiometric titration of Mohr's salt solution against	**L5:** Evaluating	1,2, 3, 4, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

CO		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	3	2	3	2	2	3	3	2	3	3
	2	3	3	-	2	3	-	-	2	2	2	3	3
	3	2	2	3	3	3	3	3	3	3	3	2	2
	4	3	3	2	3	3	3	3	2	2	3	3	3
	5	2	2	3	3	2	2	3	2	2	3	2	2
Practical	1	3	3	3	2	3	3	2	3	3	3	3	3
	2	3	3	3	3	3	3	3	3	3	3	3	2
	Average	2.7	2.7	2.4	2.6	2.8	2.3	2.3	2.6	2.6	2.7	2.7	2.8

Course Content

Semester: IV

Course name: Inorganic Chemistry-III (Theo)
Course Code: CC-IX
(Credits: Theory-04, Practicals-02)

Course Title: Inorganic Chemistry-III (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

General Principles of Metallurgy:

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining. 10 classes

Chemistry of s and p Block Elements:

Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Beryllium hydrides and halides. Boric acid and borates, boron nitrides, borohydrides (diborane) and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, phosphorus, sulphur and chlorine. Peroxo acids of sulphur. Sulphur-nitrogen compounds, Basic properties of halides and polyhalides, interhalogen compounds, polyhalides, pseudohalides, fluorocarbons and chlorofluorocarbons. 25 classes

Noble Gases:

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation, structures (VSEPR theory) and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2 and XeF_4). Xenon-oxygen compounds.

5 classes

Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes. 5 classes

Coordination Chemistry-I :

Double and complex salts. Werner's theory of coordination complexes, Classification of ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedral complexes.
15 classes

List of Practicals:

Complexometric titration

1. Zn(II)
2. Zn(II) in a Zn(II) and Cu(II) mixture
3. Ca(II) and Mg(II) in a mixture
4. Hardness of water

Inorganic preparations

1. $[Cu(CH_3CN)_4]PF_6/ClO_4$
2. Potassium dioxalatodiaquachromate(III)
3. Tetraamminecarbonatocobalt (III) ion
4. Potassium tris(oxalate)ferrate(III)
5. Tris-(ethylenediamine) nickel(II) chloride.
6. $[Mn(acac)_3]$ and $Fe(acac)_3]$ (acac= acetylacetonate)

Course Outcome (CO) Paper: CC-IX

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Understand** the occurrence of metals based on standard electrode potentials.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
2	**Use** of different methods of purification of metals like Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.	**L3:** Applying	1, 2,3, 4,5, 6, 7, 8, 9	**1, 2, 3**
3	**Describe** chemistry of s and p block elements	**L1:** Remembering	1, 2, 4, 5, 8,9	**1, 2, 3**
4	**Outline** the elementary idea about occurrence, use of noble gases, nature of bonding of noble gas compounds and their preparations including noble gases and their compounds in detail.	**L4:** Analyzing	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**
5	**Explain** inorganic polymers with types, structural aspects and their applications in detail.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
Practical				
1	**Estimate** hardness of water using complexometric titration.	**L5:** Evaluating	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Preparation** of inorganic compounds	**L6:** Creating	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
		Program Outcome (PO) & Program Specific Outcome (PSO)											
Theory	1	2	2	3	3	-	3	-	3	3	2	3	3
	2	3	3	3	3	3	2	3	2	3	2	3	3
	3	3	2	-	3	3	-	-	3	2	2	3	3
	4	2	2	2	2	2	2	3	2	3	2	2	2
	5	3	2	2	2	-	2	3	-	3	3	2	2
Practical	1	3	3	3	3	3	3	2	3	2	3	3	3
	2	3	3	3	3	3	3	3	3	3	3	3	2
	Average	2.7	2.6	2.3	2.7	2.0	2.1	2.0	2.3	2.7	2.4	2.7	2.6

Course Content

Semester: IV
Course name : Organic Chemistry-IV (Theo)

Course Code: CC-X

(Credits: Theory-04, Practicals-02)

Course Title: Organic Chemistry-IV (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Nitrogen compounds

1. Amines: Aliphatic & Aromatic: preparation, separation (Hinsberg's method) and identification of primary, secondary and tertiary amines; reaction (with mechanism): Eschweiler–Clarke methylation, diazo coupling reaction, Mannich reaction; formation and reactions of phenylenediamines, diazomethane and diazoacetic ester. 8 classes
2. Nitro compounds (aliphatic and aromatic): preparation and reaction (with mechanism): reduction under different conditions; Nef carbonyl synthesis, Henry reaction and conjugate addition of nitroalkane anion. 4 classes
3. Alkylnitrile and isonitrile: preparation and reaction (with mechanism): Thorpe nitrile condensation, von Richter reaction. 4 classes
4. Diazonium salts and their related compounds: reactions (with mechanism) involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp-Klingermann. 2 classes

Rearrangements

Mechanism with evidence and stereochemical features for the following: 1. Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, benzil-benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement. 4 classes

2. Rearrangement to electron-deficient nitrogen: rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann. 2 classes
3. Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, cumene hydroperoxide-phenol rearrangement and Dakin reaction. 2 classes
4. Aromatic rearrangements: Migration from oxygen to ring carbon: Fries rearrangement and Claisen rearrangement. 2 classes
5. Migration from nitrogen to ring carbon: Hofmann-Martius rearrangement, Fischer-Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement, Orton rearrangement and benzidine rearrangement. 3 classes
6. Rearrangement reactions by green approach: Fries rearrangement, Claisen rearrangement, Beckmann rearrangement, Baeyer-Villiger oxidation. 1 class

The Logic of Organic Synthesis

1. Retrosynthetic analysis: disconnections; synthons, donor and acceptor synthons; natural reactivity and umpolung; latent polarity in bifunctional compounds: consonant and dissonant polarity; illogical electrophiles and nucleophiles; synthetic equivalents; functional group interconversion and addition (FGI and FGA); C-C disconnections and synthesis: one-group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl); protectiondeprotection strategy (alcohol, amine, carbonyl, acid). 6 classes
2. Strategy of ring synthesis: thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique. 2 classes
3. Asymmetric synthesis: stereoselective and stereospecific reactions; diastereoselectivity and enantioselectivity (only definition); enantioselectivity: kinetically controlled MPV reduction; diastereoselectivity: addition of nucleophiles to C=O adjacent to a stereogenic centre: FelkinAnh model. 4 classes

Organic Spectroscopy

1. UV Spectroscopy: introduction; types of electronic transitions, end absorption; transition dipole moment and allowed/forbidden transitions; chromophores and auxochromes; Bathochromic and Hypsochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); application of Woodward's Rules for calculation of λmax for the following systems: conjugated diene, α,β-unsaturated aldehydes and ketones (alicyclic, homoannular and heteroannular); extended conjugated systems (dienes, aldehydes and ketones); relative positions of λmax considering conjugative effect, steric effect, solvent effect, effect of pH; effective chromophore concentration: keto-enol systems; benzenoid transitions. 4 classes
2. IR Spectroscopy: introduction; modes of molecular vibrations (fundamental and nonfundamental); IR active molecules; application of Hooke's law, force constant; fingerprint region and its significance; effect of deuteration; overtone bands; vibrational coupling in IR; characteristic and diagnostic stretching frequencies of C-H, N-H, O-H, C-O, C-N, C-X, C=C (including skeletal vibrations of aromatic compounds), C=O, C=N, N=O, C≡C, C≡N; characteristic/diagnostic bending vibrations are included; factors affecting stretching frequencies: effect of conjugation, electronic effects, mass effect, bond multiplicity, ring-size, solvent effect, H-bonding on IR absorptions; application in functional group analysis. 4 classes
3. NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR ; elementary idea about non-first-order splitting; anisotropic effects in alkene, alkyne, aldehydes and aromatics; NMR peak area, integration; relative peak positions with coupling patterns of common organic compounds (both aliphatic and benzenoid-aromatic); rapid proton exchange; interpretation of NMR spectra of simple compounds. 6 classes
4. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules. 2 classes

List of Practicals:

1. Estimation of glucose by titration using Fehling's solution
2. Estimation of vitamin-C (reduced)
3. Estimation of aromatic amine (aniline) by bromination (Bromate-Bromide) method
4. Estimation of phenol by bromination (Bromate-Bromide) method
5. Estimation of formaldehyde (Formalin)
6. Estimation of acetic acid in commercial vinegar
7. Estimation of urea (hypobromite method)
8. Estimation of saponification value of oil/fat/ester

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	Illustrate the rearrangement to electron-deficient carbon, nitrogen and oxygen atom.	L4: Analyzing	1, 2, 4, 5, 6, 7, 8, 9	1, 2, 3
2	Apply migration from nitrogen to ring carbon. Rearrangement reactions by green approach	L6: Creating	1, 2, 4, 5, 6, 7, 8, 9	1, 2, 3
3	Design retrosynthetic analysis: disconnections strategy of ring synthesis	L6: Creating	1, 2, 4, 5, 6, 7, 8, 9	1, 2, 3
4	Understand UV, IR and NMR Spectroscopy: introduction.	L2: Understanding	1, 2, 3, 4,6,8,9	1, 2, 3
5	Apply IR, UV and NMR spectroscopy for identification of simple organic molecules.	L6: Creating	1, 2, 4, 5, 6, 7, 8, 9	1, 2, 3
Practical				
1	Estimate formalin, acetic acid in commercial vinegar, urea etc.	L5: Evaluating	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
2	Estimate saponification value of oil/fat/ester.	L5: Evaluating	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	-	3	3	2	3	2	2	3	2	3
	2	2	3	2	2	2	3	3	2	3	3	2	3
	3	2	3	3	3	3	2	3	3	2	2	3	3
	4	3	2	3	3	-	3	-	2	3	2	3	2
	5	3	3	2	2	3	2	2	2	2	3	2	3
Practical	1	3	3	3	3	3	3	3	3	3	3	3	3
	2	3	3	3	3	3	3	3	3	3	3	3	3
	Average	2.7	2.8	2.3	2.7	2.4	2.6	2.4	2.4	2.6	2.7	2.6	2.8

Course Content

Semester: IV

Course Code: SEC-2

Course name: Pharmaceuticals Chemistry

(Credits: Theory-02)

Course Title: Pharmaceuticals Chemistry
(Credits: Theory-02)
F.M. = 50 (Theory-40, Internal Assesment-10)

Theory: 30 Lectures

Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti- inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT-Zidovudine). 18 classes

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C. 12 classes

Course Outcome (CO) Paper: SEC-2

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Formulate** drug discovery, design and development; Basic Retrosynthetic approach.	**L6:** Creating	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Design** the synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti- inflammatory agents, antibiotics, antibacterial and antifungal agents etc.	**L6:** Creating	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**
3	**Demonstrate** aerobic and anaerobic fermentation.	**L3:** Applying	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**
4	**Illustrate** the production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.	**L4:** Analyzing	1, 2, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3
1	3	3	2	3	2	2	3	2	2	3	2	2
2	3	3	2	2	2	3	2	3	2	3	2	2
3	2	2	3	3	3	2	3	2	3	2	3	3
4	3	3	3	3	3	3	3	2	3	3	3	3
Average	2.8	2.8	2.8	2.8	2.5	2.8	2.8	2.3	2.5	2.8	2.5	2.5

Course Content

Semester: V **Course name: Inorganic Chemistry-IV (Theo)**
Course Code: CC-XI
(Credits: Theory-04, Practicals-02)

Course Title: Inorganic Chemistry-IV (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Coordination Chemistry-II

VB description and its limitations. Elementary Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn- Teller distortion. Octahedral site stabilization energy (OSSE). Metal-ligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples). Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of dn ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea). 30 lectures

Chemistry of d- and f- block elements

Transition Elements:

General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry. 20 lectures

Lanthanoids and Actinoids:

General Comparison on Electronic configuration, oxidation states, colour, spectral and magnetic properties; lanthanide contraction, separation of lanthanides (ion-exchange method only).

List of Practicals:

Chromatography of metal ions

Principles involved in chromatographic separations.

Paper chromatographic separation of following metal ions:

1. Ni (II) and Co (II)
2. Fe (III) and Al (III)

Gravimetry

1. Estimation of nickel (II) using Dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN
3. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate) 4. Estimation of chloride

Spectrophotometry

1. Measurement of 10Dq of 3d metal complexes by spectrophotometric method.
2. Determination of λ_{max} of KMnO4 and K2Cr2O7.

Course Outcome (CO)	Paper: CC-XI

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Understand** the elementary idea of Crystal Field theory, MO concept, Magnetism, Colour, Magnetic moment and Selection rules for electronic spectral transitions etc.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
2	**Evaluate** the structures of inorganic complexes by calculating the 10Dq values.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
3	**Illustrate** and interpret the various aspects of metal coordination chemistry.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
4	**Construct** the Orgel diagrams for d^n ions and can predict the number of d-d transitions, distortion in geometry and variation of magnetic moments.	**L6:** Creating	1, 2, 3,4, 5, 6, 7, 8, 9	**1, 2, 3**
5	**Understand** the basic idea about transition elements (3d, 4d and 5d) like their electronic configuration, oxidation states and properties etc.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
Practical				
1	**Estimate** paper chromatographic separation from mixture.	**L5:** Evaluating	1, 2, 3,4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Analyze** gravimetric estimation of inorganic compounds.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	2	3	2	2	-	3	-	3	3	3	3	3
	2	3	3	2	2	2	2	2	2	2	2	3	3
	3	2	2	3	3	3	3	3	3	3	3	2	2
	4	3	3	3	3	3	3	3	2	2	2	3	3
	5	3	2	2	-	-	2	-	2	2	2	3	2
Practical	1	3	3	3	3	3	3	3	3	3	3	2	3
	2	3	3	3	3	3	3	3	3	3	3	3	3
	Average	2.7	2.7	2.6	2.3	2.0	2.7	2.0	2.6	2.6	2.6	2.7	2.7

Course Content

Semester: V
Course name : Organic Chemistry-V (Theo)

Course Code: CC-XII
(Credits: Theory-04, Practicals-02)

Course Title: Organic Chemistry-V (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Carbocycles and Heterocycles

1. Polynuclear hydrocarbons and their derivatives: synthetic methods include Haworth, Bardhan Sengupta and other useful syntheses (with mechanistic details); fixation of double bonds and Fries rule; reactions (with mechanism) of naphthalene, anthracene, phenanthrene and their derivatives. 4 classes

2. Heterocyclic compounds: 5- and 6-membered rings with one heteroatom; reactivity, orientation and important reactions (with mechanism) of furan, pyrrole, thiophene and pyridine; synthesis (including retrosynthetic approach and mechanistic details): pyrrole: Knorr synthesis, Paal-Knorr synthesis, Hantzsch; furan: Paal-Knorr synthesis, Feist-Benary synthesis and its variation; thiophenes: Paal-Knorr synthesis, Hinsberg synthesis; pyridine: Hantzsch synthesis; benzo-fused 5- and 6-membered rings with one heteroatom: reactivity, orientation and important reactions (with mechanistic details) of indole, quinoline and isoquinoline; synthesis (including retrosynthetic approach and mechanistic details): indole: Fischer, Madelung and Reissert; quinoline: Skraup, Doebner- Miller, Friedlander; isoquinoline: Bischler-Napieralski synthesis. Cyclic Stereochemistry Alicyclic compounds: concept of I-strain; conformational analysis: cyclohexane, mono and disubstituted cyclohexane; symmetry properties and optical activity; ring-size and ease of cyclisation; conformation & reactivity in cyclohexane system: consideration of steric and stereoelectronic requirements; elimination (E2, E1), nucleophilic substitution (SN1, SN2, SNi, NGP), merged substitution-elimination; rearrangements; oxidation of cyclohexanol, esterification, saponification, lactonisation, epoxidation, pyrolytic syn elimination and fragmentation reactions. 12 classes

Pericyclic reactions

Mechanism, stereochemistry, regioselectivity in case of 10 classes

1. Electrocyclic reactions: FMO approach involving 4π- and 6π-electrons (thermal and photochemical) and corresponding cycloreversion reactions.
2. Cycloaddition reactions: FMO approach, Diels-Alder reaction, photochemical [2+2] cycloadditions.
3. Sigmatropic reactions: FMO approach, sigmatropic shifts and their order; [1,3]- and [1,5]-H shifts and [3,3]-shifts with reference to Claisen and Cope rearrangements.

Carbohydrates

1. Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect (including stereoelectronic explanation); mutarotation; epimerization; reactions (mechanisms in relevant cases): Fischer glycosidation, osazone formation, bromine-water oxidation, HNO_3 oxidation, selective oxidation of terminal –CH_2OH of aldoses, reduction to alditols, Lobry de Bruyn-van Ekenstein rearrangement; stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's & Wohl's methods) of aldoses; acetonide (isopropylidene) and benzylidene protections; ring-size determination; Fischer's proof of configuration of (+)-glucose. 8 classes

Biomolecules

1. Amino acids: synthesis with mechanistic details: Strecker, Gabriel, acetamido malonic ester, azlactone, Bücherer hydantoin synthesis, synthesis involving diketopiperazine; isoelectric point, zwitterions; electrophoresis, reaction (with mechanism): ninhydrin reaction; resolution of racemic amino acids. 4 classes

2. Peptides: peptide linkage and its geometry; syntheses (with mechanistic details) of peptides using N-protection & C-protection, solid-phase (Merrifield) synthesis; peptide sequence: Cterminal and N-terminal unit determination (Edman, Sanger & 'dansyl' methods); partial hydrolysis; specific cleavage of peptides: use of CNBr. 4 classes

3. Nucleic acids: pyrimidine and purine bases (only structure & nomenclature); nucleosides and nucleotides corresponding to DNA and RNA; elementary idea of double helical structure of DNA (Watson-Crick model); complimentary base–pairing in DNA. Alkaloids and Terpenoids General studies on terpenoids and alkaloids; determination of structure of α-Terpenol and ephedrine.

List of Practical

Chromatographic Separations

1. TLC separation of a mixture containing 2/3 amino acids
2. TLC separation of a mixture of dyes (fluorescein and methylene blue)
3. Column chromatographic separation of mixture of dyes
4. Paper chromatographic separation of a mixture containing 2/3 amino acids

Spectroscopic Analysis of Organic Compounds

1. Assignment of labelled peaks in the 1H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.

2. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N stretching frequencies; characteristic bending vibrations are included).

3. The students must record full spectral analysis of at least 15 (fifteen) compounds from the following list:

a. 4-Bromoacetanilide b. 2/ -Bromo-4/ -methylacetophenone c. Vanillin d. 2/ -Methoxyacetophenone e. 4-Aminobenzoic acid f. Salicylamide g. 2/ -Hydroxyacetophenone h. 1,3-Dinitrobenzene i. Benzylacetate j. trans-4-Nitrocinnamaldehyde k. Diethyl fumarate l. 4-Nitrobenzaldehyde m. 4-Methylacetanilide n. Mesityl oxide o. 2-Hydroxybenzaldehyde p. 4-Nitroaniline 75 q. 2-Hydroxy-3-nitrobenzaldehyde r. 2,3-Dimethylbenzonitrile s. Pent-1-yn-3-ol t. 3-Nitrobenzaldehyde u. 3-Ethoxy-4-hydroxybenzaldehyde v. 2-Methoxybenzaldehyde w. Methyl 4-hydroxybenzoate x. Methyl 3-hydroxybenzoate y. 3-Aminobenzoic acid z. Ethyl 3-aminobenzoate aa. Ethyl 4-aminobenzoate bb. 3-nitroanisole cc. 5-Methyl-2-nitroanisole dd. 3-Methylacetanilide

Course Outcome (CO)	Paper: CC-XII

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Outline** pericyclic reactions with mechanism, stereochemistry and regioselectivity	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Identify** ring structure and reactions of monosaccharides including structure of D-glucose & D-fructose (configuration & conformation);	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
3	**Construct** reaction of carbohydrates towards biological aspects	**L6:** Cerating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
4	**Explain** amino acids and peptides and their natural occurrence including synthesis	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
5	**Illustrate** the biological phenomena of nucleic acids.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
Practical				
1	**Analysis of** 1H NMR spectra and IR spectra of the known organic compounds.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Predict** unknown organic compounds through full spectral analysis.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO 1	PSO 2	PSO 3
		Program Outcome (PO) & Program Specific Outcome (PSO)											
Theory	1	3	3	2	2	2	3	3	2	3	2	2	3
	2	2	3	2	3	3	2	2	3	2	2	2	3
	3	3	2	3	3	3	3	3	3	3	3	3	2
	4	2	2	3	3	-	2	-	2	3	3	3	2
	5	3	3	2	2	2	3	2	2	2	2	2	3
Practical	1	3	3	3	3	3	2	3	3	3	3	3	3
	2	3	3	3	3	2	2	3	2	3	3	3	3
	Average	2.7	2.7	2.6	2.7	2.1	2.4	2.3	2.4	2.7	2.6	2.8	2.7

Course Content

Semester: V

Course name: Advanced Physical Chemistry (Theo)
Course Code: DSE-1
(Credits: Theory-04, Practicals-02)

Course Title: Advanced Physical Chemistry (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Crystal Structure

1. Bravais Lattice and Laws of Crystallography: Types of solid, Bragg's law of diffraction; Laws of crystallography (Hany's law and Steno's law); Permissible symmetry axes in crystals; Lattice, space lattice, unit cell, crystal planes, Bravais lattice. Packing of uniform hard sphere, close packed arrangements (fcc and hcp); Tetrahedral and octahedral voids.
2.Crystal planes: Distance between consecutive planes [cubic, tetragonal, and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of dhkl; Relation between molar mass andunit cell dimension for cubic system; Bragg's law (derivation).
3. Determination of crystal structure: Powder method; Structure of NaCl and KCl crystals.

Statistical Thermodynamics.

1. Configuration: Macrostates, microstates and configuration; calculation with harmonic oscillator; variation of W with E; equilibrium configuration..
2. Boltzmann distribution: Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution; Partition function, concept of ensemble - canonical ensemble.
3. Partition function: molecular partition function and thermodynamic properties, Maxwell's speed distribution; Gibbs' paradox.

Special selected topics

1. Specific heat of solid: Coefficient of thermal expansion, thermal compressibility of solids; Dulong –Petit's law; Perfect Crystal model, Einstein's theory – derivation from partition function, limitations; Debye's T3 law – analysis at the two extremes (without derivation of T3 law).
2. 3rd law: Absolute entropy, Planck's law, Calculation of entropy, Nernst heat theorem.
3. Polymers: Classification of polymers, nomenclature, Molecular forces, and chemical bonding in polymers, Texture of Polymers; Criteria for synthetic polymer formation; Relationships between functionality, extent of reaction and degree of polymerization; Mechanism and kinetics of step growth and copolymerization; Conducting polymers.
4. Dipole moment and polarizability: Polarizability of atoms and molecules, dielectric constant and polarization, molar polarization for polar and non-polar molecules; Clausius-Mosotti equation and Debye equation (both without derivation) and their application; Determination of dipole moments.

List of Practical

Computer Programming based on numerical methods for:

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid)
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations)
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values
4. Matrix operations (Application of Gauss-Siedel method in colourimetry)

Course Outcome (CO) **Paper: DSE-1**

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Measure** the packing fraction of different lattice systems.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Label**the distinction of various lattice defects and its origin.	**L1:** Remembering	1, 2, 4, 5, 8,9	**1, 2, 3**
3	**Create**the nomenclature of Polymers.	**L6:** Creating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
4	**Estimate**the residual entropy of various complicated chemical moieties	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
5	**Evaluate**the specific heat of solid.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
Practical				
1	**Determination** of roots of equations.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Implementation of** various mathematical tools on chemical problems	**L6:** Creating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	2	3	2	3	3	3	2	3	2	3	2
	2	3	2	-	3	2	-	-	3	2	2	3	2
	3	2	3	3	3	3	3	2	2	3	3	3	3
	4	3	3	2	3	3	2	3	2	2	3	3	3
	5	2	3	2	2	2	3	2	2	3	3	2	3
Practical	1	3	3	3	3	3	3	3	3	2	3	3	3
	2	3	3	3	3	2	3	3	3	3	3	3	3
	Average	2.7	2.7	2.3	2.7	2.6	2.4	2.3	2.4	2.6	2.7	2.9	2.7

Course Content

Semester: V

Course Code: DSE-2

Course Name: Analytical methods in Chemistry

(Credits: Theory-04, Practical:02)

Code: DSE-2
Course Title: Analytical methods in Chemistry
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Qualitative and quantitative aspects of analysis

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution, indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals. 6 classes

Optical methods of analysis

1. Origin of spectra, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
2. UV-Visible Spectrophotometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.
3. Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.
4. Infrared Spectroscopy: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

5. Flame Atomic Absorption and Emission Spectroscopy: Basic principles of instrumentation (choice of source, monochromator, and detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; background correction, sources of chemical interferences and their removal. Techniques for the quantitative estimation of trace level of metal ions from environmental samples. 18 classes

Thermal methods of analysis

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. 6 classes

Electroanalytical methods

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.

Techniques used for the determination of pKa values. 7 classes

Separation techniques

1. Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation.
2. Technique of extraction: batch, continuous and counter current extractions.
3. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.
4. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange.
5. Development of chromatograms: frontal, elution and displacement methods.
6. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC, LC, GLC and HPLC.
7. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).
8. Role of computers in instrumental methods of analysis.

List of Practicals:

Separation Techniques - Chromatography

1. Separation of mixtures Separation and identification of the monosaccharides in a mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
2. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.
3. Separation of the active ingredients of plants, flowers and juices by TLC

Solvent Extractions

1. To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.
2. Analysis of soil:

a. Determination of pH of soil.

b. Total soluble salt c. Estimation of calcium, magnesium, phosphate, nitrate

3. Ion exchange: a. Determination of exchange capacity of cation exchange resins and anion exchange resins.

Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry
2. Determination of chemical oxygen demand (COD)
3. Determination of Biological oxygen demand

Course Outcome (CO) Paper: DSE-2

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	Understand the basic idea of analytical chemistry, sampling, accuracy and precision, sources of errors in analytical measurements.	L2: Understanding	1, 2, 3, 4,6,8,9	1, 2, 3
2	Infer the fundamental laws of spectroscopy and selection rules.	L2: Understanding	1, 2, 3, 4,6,8,9	1, 2, 3
3	Identify the chemical compounds by applying theories of UV and IR spectroscopy.	L4: Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
4	Apply different analytical methods (Flame Atomic Absorption and Emission Spectrometry, Thermogravimetry, pH metric, Potentiometric and Conductometric Titrations) to identify and separate the products formed during different chemical transformations.	L3: Applying	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
5	Determine the pKa values of indicators by using pH metric, potentiometric and conductometric titrations.	L5: Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
Practical				
1	Determine concentration, analysis pH of soil, total soluble salt etc, by spectrophotometry.	L6: Creating	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
2	Design ion exchange method for determination of exchange capacity of cation exchange resins and anion exchange resins.	L6: Creating	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3

Programme Articulation Matrix (CO-PO Matrix)

Programme Articulation Matrix (CO-PO Matrix)													
	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
Theory	1	3	2	2	2	-	2	-	3	3	3	2	2
	2	3	3	2	-	-	2	-	2	2	2	3	3
	3	3	3	3	3	3	2	3	2	3	3	3	2
	4	3	3	3	3	2	3	3	2	2	2	3	3
	5	2	2	3	2	3	3	2	2	2	2	3	3
Practical	1	2	3	3	3	3	3	3	3	3	3	3	3
	2	3	3	2	3	3	3	3	3	3	3	2	3
	Average	2.7	2.7	2.6	2.3	2.0	2.6	2.4	2.4	2.6	2.6	2.7	2.7

Course Content

Semester: VI **Course name: Inorganic Chemistry-V (Theo)**
Course Code: CC-XIII
(Credits: Theory-04, Practicals-02)

Course Title: Inorganic Chemistry-V (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Bioinorganic Chemistry

Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+})in biological systems. Metal ion transport across biological membrane Na^+/K^+-ion pump. Oxygen transport in biological systems: Haemoglobin, Myoglobin, Hemocyanine and Hemerythrin. Electron transfer proteins: Cytochromes and Ferredoxins. Hydrolytic enzymes: carbonate bicarbonate buffering system, carbonic anhydrase and carboxyanhydrase A. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases (examples only). 25 classes

Organometallic Chemistry

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. 18-electron and 16-electron rules (pictorial MO approach). Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls. π-acceptor properties of CO, synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation, structure, evidences of synergic effect.
Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertion reactions.

15 classes

Catalysis by Organometallic Compounds

Study of the following industrial processes
1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Ziegler-Natta catalysis for olefin polymerization. 10 classes

Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect and its application in complex synthesis, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution reactions, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.
,. 10 classes

List of Practicals:

Qualitative semimicro analysis

Qualitative semimicro analysis of mixtures containing four radicals. Emphasis should be given to the understanding of the chemistry of different reactions and to assign the most probable composition.

Cation Radicals: Na^+, K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Al^{3+}, Cr^{2+}, Mn^{2+}/Mn^{4+}, Fe^{3+}, Co^{2+}/Co^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}/Sn^{4+}, As^{3+}/As^{5+}, $Sb^{3+/5+}$, NH_4^+, Mg^{2+}.

Anion Radicals: F^-, Cl^-, Br^-, BrO_3^-, I^-, IO_3^-, SCN^-, S^{2-}, SO_4^{2-}, NO_3^-, NO_2^-, PO_4^{3-}, AsO_4^{3-}, BO_3^{3-}, $CrO_4^{2-}/Cr_2O_7^{2-}$, $Fe(CN)_6^{4-}$, $Fe(CN)_6^{3-}$.

Insoluble Materials: Al_2O_3(ig), Fe_2O_3(ig), Cr_2O_3(ig), SnO_2, $SrSO_4$, $BaSO_4$, CaF_2, $PbSO_4$.

Course Outcome (CO) Paper: CC-XIII

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Demonstrate** the role of essential and beneficial elements in our life and various types of proteins and their activities.	**L3:** Applying	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Value and draw** diagrams of different bio-active inorganic compounds.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
3	**Understand** the preparation mono and binuclear carbonyls of 3d series and structures of mononuclear and binuclear carbonyls applying IR data.	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
4	**Illustrate** the idea about different types of organometallic compounds and their preparation and their applications as catalysis in various industrial processes.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
5	**Summarize** and justify Organometallic chemistry.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
Practical				
1	**Identify** experimentally the known & unknown radicals and insoluble materials in a mixture.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Summarize** the effect of common ions and solubility products in precipitation and separation of basic radicals into different groups.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	2	3	2	3	2	2	3	3	3	3	3
	2	3	2	3	2	2	3	3	2	2	2	3	2
	3	2	2	2	3	-	2	-	3	2	2	2	2
	4	3	3	3	3	3	3	2	2	3	3	3	3
	5	2	3	2	2	2	2	3	2	3	2	2	3
Practical	1	3	3	3	3	3	3	3	3	3	3	3	3
	2	3	3	3	3	3	3	3	3	3	3	3	3
	Average	2.7	2.6	2.7	2.6	2.3	2.6	2.3	2.6	2.7	2.6	2.7	2.7

Course Content

Semester: VI **Course name: Physical Chemistry-IV (Theo)**
Course Code: CC-XIV
(Credits: Theory-04, Practicals-02)

Course Title: Physical Chemistry-IV (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Molecular Spectroscopy

1. Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation
2. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution
3. Vibrational spectroscopy: Classical equation of vibration, computation of force constant,amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration.
4. Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes, and anti-Stokes lines; their intensity difference, rule of mutual Exclusion
5. Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra.

Photochemistry

1. Lambert-Beer's law: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients; Laws of photochemistry, Stark Einstein law of photochemical equivalence quantum yield, actinometry, examples of low and high quantum yields
2. Photochemical Processes: Potential energy curves (diatomic molecules), Frank-Condon principle and vibrational structure of electronic spectra; Bond dissociation and principle of determination of dissociation energy (ground state); Decay of excited states by radiative and non-radiative paths; Pre-dissociation; Fluorescence and phosphorescence, Jablonski diagram.
3. Rate of Photochemical processes: Photochemical equilibrium and the differential rate of photochemical reactions, Photo stationary state; HI decomposition, H2-Br2 reaction, dimerization of anthracene; photosensitized reactions, quenching; Role of photochemical reactions in biochemical processes, photo stationary states, chemiluminescence.

Surface phenomenon

1. Surface tension and energy: Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading of liquid over other surfaces.m Vapour pressure over curved surface; Temperature dependence of surface tension
2. Adsorption: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms: multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogenous catalysis (single reactant); Zero order and fractional order reactions.
3. Colloids: Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Determination of Avogadro number by Perrin's method; Stability of colloids and zeta potential; Micelle formation

List of Practical

1. Determination of surface tension of a liquid using Stalagmometer.
2. Determination of CMC from surface tension measurements.
3. Verification of Beer and Lambert's Law for $KMnO_4$ and $K_2Cr_2O_7$ solution.
4. Determination of pH of unknown buffer, spectrophotometrically.

Course Outcome (CO)	Paper: CC- XIV

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	**Design** the photophysical and photochemical path through proper naming.	**L6:** Creating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Measure** quantum yield of various photophysical phenomena.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
3	**Predict** the surface tension of unknown liquid using Stalagmometer.	**L5:** Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
4	**Compose** the various equation of isotherm to study the nature of adsorption.	**L6:** Creating	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
5	**Demonstrate** the sound knowledge on the behavior of Micelle	**L2:** Understanding	1, 2, 3, 4,6,8,9	**1, 2, 3**
Practical				
1	**Compute** the Concentration of unknown strength of the same type solution from plot of ***Abs.(A) Vs. Conc.(C)***	**L3:** Applying	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**
2	**Differentiate** the strength of unknown buffer soln. using their pH values.	**L4:** Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	**1, 2, 3**

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO8	PO9	PSO 1	PSO 2	PSO 3
Theory	1	3	3	2	2	3	2	2	2	2	2	2	3
	2	3	2	2	2	2	3	2	2	3	2	2	2
	3	2	2	3	3	3	2	3	3	2	3	3	3
	4	2	3	3	3	3	3	2	3	2	3	2	2
	5	3	2	2	3	-	2	-	2	3	3	3	3
Practical	1	3	3	3	3	3	3	3	3	2	3	3	3
	2	3	3	2	3	3	3	3	3	3	3	3	3
	Average	2.7	2.6	2.4	2.7	2.4	2.6	2.1	2.6	2.4	2.7	2.6	2.7

Course Content

Semester: VI **Course name: Polymer Chemistry (Theo) Course Code: DSE-3**
(Credits: Theory-06)

Course Title: Polymer Chemistry (Theo)
(Credits: Theory-04, Practical-02)
F.M. = 75 (Theory-40, Practical-20, Internal Assesment-15)

Theory: 60 Lectures

Introduction and history of polymeric materials

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. 4 classes

Functionality and its importance

\Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.

4 classes

Kinetics of Polymerization

Mechanism and kinetics of step growth, radical chain growth, kinetics of copolymerization, polymerization techniques. 4 classes

Determination of molecular weight of polymers

Mn, Mw, etc. (by end group analysis), viscometry, osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

4 classes

Glass transition temperature (Tg) and determination of Tg

Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

4 classes

Polymer Solution

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions. 2 classes

Properties of Polymer (Physical, thermal, Flow & Mechanical Properties)

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers. Polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac). Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)]. 38 classes

List of Practicals:

Polymer Synthesis

1. Preparation of nylon 66/6
2. Preparations of novalac resin/ resold resin.

Polymer Characterization

1. Determination of molecular weight by viscometry:
a. Polyacrylamide-aq.$NaNO_2$ solution
b. (Poly vinyl proplylidine (PVP) in water
2. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer Analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method.

Course Outcome (CO) Paper: DSE-3

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	Describe introduction and history of polymeric materials.	L1: Remembering	1, 2, 4, 5, 8,9	1, 2, 3
2	Illustrate functionality, importance and criteria for synthetic polymer formation, classification of polymerization processes.	L4: Analyzing	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
3	Depict the kinetics of polymerization and mechanism of step growth, radical chain growth, copolymerization, polymerization techniques.	L5: Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
4	Understand various processes involved regarding molecular weight determination of polymers.	L2: Understanding	1, 2, 3, 4,6,8,9	1, 2, 3
5	Predict glass transition temperature (T_g) and its determination.	L5: Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
Practical				
1	Apply the knowledge of polymer synthesis.	L3: Applying	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3
2	Estimate molecular weigh tof different polymers by viscometric analysis.	L5: Evaluating	1, 2,3, 4, 5, 6, 7, 8, 9	1, 2, 3

Programme Articulation Matrix (CO-PO Matrix)

	CO	Program Outcome (PO) & Program Specific Outcome (PSO)											
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
Theory	1	3	2	-	2	2	-	-	3	3	3	2	2
	2	3	3	2	2	3	3	2	2	2	2	3	3
	3	3	3	3	3	3	2	3	3	2	3	3	2
	4	3	3	3	3	-	2	3	-	2	2	3	3
	5	2	2	3	3	3	3	2	2	2	2	3	3
Practical	1	2	3	3	3	3	2	3	3	3	3	3	3
	2	3	3	2	3	3	3	3	3	3	3	2	3
	Average	2.7	2.7	2.3	2.7	2.4	2.1	2.3	2.3	2.1	2.6	2.7	2.7

Course Content

Semester: VI **Course name: Dissertation followed by power point presentation**
Course Code: DSE-4
(Credits: Theory-06

Course Title: Dissertation followed by power point presentation
(Credits: 06)
F.M. = 75

Total: (60+30)= 90 Lectures

1. Dissertation writing. 60 classes
2. Power point presentation: preparation of slides. 30 classes

Course Outcome (CO) Paper: DSE-4

Sl. No.	Course Outcome (CO)	Knowledge Level	POs	PSOs
Theory				
1	Identify a brief idea on Dissertation and how to write?	L4: Analyzing	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
2	Summarize the collected sample materials of common dissertation with the help of regular Journal club.	L5: Evaluating	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
3	Judge the topic of literature review: How, what and where?	L5: Evaluating	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
4	Discover knowledge on power point presentation: How to prepare?	L3: Applying	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
5	Prepare samples of common presentation slides.	L3: Applying	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
6	Compose art of presentation	L6: Creating	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3
7	Develop a visionary idea about a dissertation followed by power point presentation on a research topic	L6: Creating	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3

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	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3
1	3	3	2	2	3	2	2	2	2	3	3	3
2	3	3	2	2	2	2	3	2	3	3	3	2
3	2	2	3	3	3	3	3	3	3	2	2	2
4	2	2	3	3	3	2	2	3	3	3	2	3
5	3	3	3	3	3	3	3	3	3	3	3	3
1	3	2	3	3	3	3	3	3	3	3	3	2
2	3	3	3	3	3	3	3	2	3	2	3	3
Average	2.7	2.6	2.7	2.7	2.9	2.6	2.7	2.6	2.9	2.9	2.7	2.6