B. Sc. (Honors) with Chemistry

Program Specific Outcomes (PSO):

(a) Increasing chemical understanding via theory and practical.

(b) Identifying molecules in terms of nomenclature, stereochemistry, structures, reactivity, and chemical reaction mechanisms.

(c) Understanding chemical formulas and structures, as well as answering numerical difficulties.

(d) Understanding of proper laboratory practice and safety.

(e) Improving research abilities.

(f) Recognition and use of complex equipment and advanced instruments.

(g) Learning the skill to deliver presentation lectures.

Class/ Paper/ Semester	**Title**	**Course Outcome (CO)**
		Chemistry UG (CBCS) Semester-I
CHEMISTRY-UG PAPER-CHEMHT-1 (Theory) Sem-I	Inorganic-1A	Upon completion of the course, students will be able to learn: • Bohr's model and atomic spectrum of hydrogen, Limitations of Bohr's model • Sommerfeld's modifications, de Broglie's concept, Heisenberg's uncertainty principle and its significance, Time independent Schrödinger's wave equation • Significance of ψ and ψ^2, Radial and angular wave functions for the hydrogen atom (qualitative idea), radial probability distribution curves, shapes of s, p, d and f orbitals (qualitative idea), • Quantum numbers and their significance, Pauli's exclusion principle, Aufbau principle and limitations, Hund's rules, exchange energy, and electronic configurations of atoms. • Elementary idea of microstates.
		Upon completion of the course, students will be able to learn to know: • Understand the nature of elements and their different properties, periodic variation of the properties etc. • Modern IUPAC periodic table and classification of elements in the table; • Effective nuclear charge and its calculation using Slater's rules; • Atomic radii, Ionic radii and Pauling's method for determining univalent ionic radii; • Electronegativity (Pauling's, Mulliken's, Allred-Rochow's and Sanderson's scales) and its applications, Ionization energy, Electron affinity and factors influencing these properties; Group trends and periodic trends of these properties with reference to s, p and d-block elements. Secondary periodicity; • Inert pair effect
	Physical – 1A	Upon completion of the course, students will be able to learn: • 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). • 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. 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 o 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).
		Upon completion of the course, students will be able to learn: • 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. • 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 the effect of pressure on enthalpy of reactions.
CHEMISTRY-UG PAPER-CHEMHP-1 (Practical) Sem-I	Inorganic-1A	Upon completion of the course, students will be able to learn: i. Method of preparation of standard solutions of titrants ii. Estimation of carbonate and hydroxide present together in a mixture iii. Estimation of carbonate and bicarbonate present together in a mixture
	Physical – 1A	Upon completion of the course, students will be able to learn: i. Determination of pH of the unknown solution (buffer), by the colour matching method. ii. Determination of heat of neutralization of a strong acid by a strong base. iii. Determination of heat of solute ion of oxalic acid from solubility measurement.
CHEMISTRY-UG PAPER-CHEMHT-2 (Theory) Sem-I	Organic - 1	Upon completion of the course, students will be able to know: **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 (sp^3, sp^2, sp: C-C, C-N & C-O systems and s-cis and s-trans geometry for suitable cases). **Electronic displacements:** Inductive effect, field effect, mesomeric effect, resonance energy; bond polarization and bond polarizability; electromeric effect; steric effect, steric inhibition of resonance. **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
		Upon completion of the course, students will be able to learn: • 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
		Upon completion of the course, students will be able to learn: • Bonding geometries of carbon compounds and representation of molecules • Concept of chirality and symmetry • Relative and absolute configuration • Optical activity of chiral compounds
CHEMISTRY-UG PAPER-CHEMHP-2 (Practical) Sem-I	Organic - 1	Upon completion of the course, students will be able to learn: **1. Separation:** Based upon solubility, by using common laboratory reagents 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; etc. **2. Determination of boiling point:** Determination of boiling point of common organic liquid compounds e.g., ethanol, cyclohexane, chloroform, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide, etc. [Boiling point of the chosen organic compounds should preferably be less than 160 °C] **3. Identification of a Pure Organic Compound by chemical test(s):** **Solid compounds:** oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid. **Liquid Compounds:** formic acid, acetic acid, methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene.
Chemistry UG (CBCS) Semester-II		
CHEMISTRY-UG PAPER-CHEMHT-3 (Theory) Sem-II	Inorganic-1B	Upon completion of the course, students will be able to learn: • Qualitative idea about complimentary, noncomplimentary, disproportionation and comproportionation reactions, standard redox potentials with sign • conventions, Electrochemical series and its application to explore the feasibility of reactions and equilibrium constants, Nernst equation; effect of pH, • complexation and precipitation on redox potentials, formal potential; Basis of redox titration and redox indicators, Redox potential diagrams (Latimer and Frost) of common elements and their applications. • Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulphides, carbonates, sulphates and halides
		Upon completion of the course, students will be able to learn:

		• Recapitulation of Arrhenius concept, Bronsted-Lowry concept, Solvent system concept, Lux-Flood concept, Lewis concept, Drago-Wayland equation, • Solvent levelling and differentiating effects, Relative strength of different acids and bases, Pauling's rules, Hammett acidity function and super acids, HSAB principle and its applications, Acid-base equilibria in aqueous solution, pH, Buffer, Acid-base neutralization curves and choice of indicators. Gas phase acidity
	Physical – 1B	Upon completion of the course, students will be able to learn: • 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; 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. 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.
		Upon completion of the course, students will be able to learn: • 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 catalyzed 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 firs order). 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). • Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number
CHEMISTRY-UG PAPER-CHEMHP-3 (Practical) Sem-II	Inorganic-1B	Upon completion of the course, students will be able to learn: i. Estimation of Fe(II) using $K_2Cr_2O_7$ solution ii. Estimation of Fe(III) using $K_2Cr_2O_7$ and $KMnO_4$ solution iii. Estimation of Ca^{2+} using $KMnO_4$ solution iv. Estimation of Cu^{2+} iodometrically v. Estimation of Cr^{3+} using $K_2Cr_2O_7$ solution
	Physical – 1B	Upon completion of the course, students will be able to learn: i. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate. ii. Study of kinetics of decomposition of H_2O_2.
CHEMISTRY-UG PAPER-CHEMHT-4	Organic - II	Upon completion of the course, students will be able to learn: • Chirality arising out of stereoaxis: Stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in

(Theory) Sem-II		allenes, spiro compounds, alkylidenecycloalkanes and biphenyls; related configurational descriptors (Ra/Sa and P/M); atropisomerism; the racemisation of chiral biphenyls; buttressing effect. • Concept of prostereoisomerism: • Prostereogeniccentre; concept of pron-chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-r and pros descriptors of ligands on propseudoasymmetriccentre. • 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, 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).
		Upon completion of the course, students will be able to learn: • Reaction thermodynamics: • Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions. • 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 nucleophilicity and basicity; • HSAB principle; application of thermodynamic principles in acid-base equilibria. Tautomerism: Prototropy (keto-enol, nitro - aci-nitro, nitroso-oximino, diazo-amino and enamine-imine systems); valence tautomerism 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. 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;
		Upon completion of the course, students will be able to learn: • Free-radical substitution reaction: Halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate. Nucleophilic substitution reactions: Substitution at sp3 centre: mechanisms (with evidence), relative rates & stereochemical featureseffects 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]. • Concept of aliphatic electrophilic substitution reactions (SE1, SE2, SEi). Elimination reactions); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/ Hofmann) and stereoselectivity; comparison between substitution and elimination; importance of Bredt's rule relating to the formation of C=C
CHEMISTRY-UG PAPER-CHEMHP-4 (Practical)	Organic - II	Upon completion of the course, students will be able to learn: Organic Preparations: A. The following reactions are to be performed, noting the yield of the crude

Sem-II		product: 1. Nitration of aromatic compounds 2. Condensation reactions 3. Hydrolysis of amides/imides/esters 4. Acetylation of phenols/aromatic amines 5. Benzoylation of phenols/aromatic amines 6. Side chain oxidation of aromatic compounds 7. Diazo coupling reactions of aromatic amines 8. Bromination of anilides using green approach (Bromate-Bromide method) 9. Redox reaction including the solid-phase method 10. Green 'multi-component-coupling' reaction 11. 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.
Chemistry UG (CBCS) Semester-III		
CHEMISTRY-UG PAPER-CHEMHT-5 (Theory) Sem-III	Physical – II	Upon completion of the course, students will be able to learn: • Viscosity: General features of fluid flow (streamline flow and turbulent flow); Newton's equation, 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. Conductance and transport number: Ion conductance; Conductance and measurement of conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; • Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Debye –Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, relaxation effect and electrophoretic effect; Ostwald's dilution law; Ionic mobility; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations.
		Upon completion of the course, students will be able to learn: • Partial properties and chemical potential: Chemical potential and activity, partial molar quantities, 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 V during mixing for binary solutions. • 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 KP, KC and KX; Van't Hoff's reaction isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas;

		• Le Chatelier's principle. Nernst's distribution law; Application-(finding out Keq using Nernst distribution law for $KI+I_2 = KI_3$ and dimerization of benzene. Chemical potential and other properties of ideal substances-pure and mixtures: Pure ideal gas: Its chemical potential and other thermodynamic functions and their changes during a change of thermodynamic parameters of mixing; Chemical potential of an ideal gas in an ideal gas mixture; Concept of standard states and choice of standard states of ideal gases. • 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.
		Upon completion of the course, students will be able to learn: • <u>Beginning of Quantum Mechanics</u>: Wave-particle duality, light as particles: photoelectric and compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (without proof). • <u>Wave function</u>: Schrodinger time-independent equation; nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function. • <u>Concept of Operators</u>: Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators; Commutation of operators, commutator and uncertainty relation; Expectation value; Hermitian operator; Postulates of Quantum Mechanics. • <u>Particle in a box</u>: Setting up of Schrodinger equation for one-dimensional box and its solution; Comparison with free particle eigenfunctions and eigenvalues. Properties of particle in a box wave functions (normalisation, 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
CHEMISTRY-UG PAPER-CHEMHP-5 (Practical) Sem-III	Physical – II	Upon completion of the course, students will be able to learn: i. Study of viscosity of unknown liquid (glycerol, sugar) with respect to water. ii. Determination of partition coefficient for the distribution of I_2 between water and CCl_4. iii. Determination of K_{eq} for $KI + I_2 = KI_3$, using partition coefficient between water and CCl_4. Iv. Conductometric titration of an acid (strong, weak/ monobasic, dibasic) against strong base. v. Study of saponification reaction conductometrically. vi. Verification of Ostwald's dilution law and determination of K_a of weak acid.
CHEMISTRY-UG PAPER-CHEMHT-6 (Theory) Sem-III	Inorganic - II	Upon completion of the course, students will be able to learn: • Ionic Bond: Lattice energy, Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy, Born-Haber cycle and its applications, Polarising power and polarisability of ions, Fajan's rules and its applications, radius ratio rules – its applications and limitations, salvation energy and solubility energetics of dissolution process; • Packing in crystals, voids in crystal lattice, packing efficiency, Structure of ionic solids: rock salt, zinc blende, wurtzite, fluorite, antifluorite,

		perovskite and layer lattice. Qualitative idea about stoichiometric and non-stoichiometric crystal defects.
		Upon completion of the course, students will be able to learn: • Covalent Bond: Lewis structures, formal charge; Qualitative idea of V.B.Theory, directional properties of covalent bond, Concept of Equivalent and non equivalent Hybridization and shapes of simple molecules and ions (examples from main groups), Stereochemically non-rigid molecules – Berry's pseudorotation, Resonance and Dipole moments of inorganic molecules and ions, • VSEPR theory and Bent's rule and their applications; M.O. Theory (elementary pictorial approach), concept of bond order, MO diagram of homo-nuclear diatomics (1^{st} and 2^{nd} period elements), hetero-nuclear diatomics (HF, CO, NO, NO^+ and CN^-) and triatomics (H_2O and BeH_2). Electron sea model and elementary idea about band theory, classification of inorganic solids and their conduction properties according to band theory; Hydrogen bonding: classifications, its effect on the properties of compounds and its importance in biological systems, vander Waal's forces
		Upon completion of the course, students will be able to learn: • Idea about ores and minerals, operations involved in metallurgy, Flow chart diagram for the extraction of pure Ti, Ni and U(including reactions) from their important ores and their uses.
CHEMISTRY-UG PAPER-CHEMHP-6 (Practical) Sem-III	Inorganic - II	Upon completion of the course, students will be able to learn: i. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution ii. Estimation of Fe(III) and Cu(II) in a given mixture using $K_2Cr_2O_7$ solution iii. Estimation of Cr(VI) and Mn(II) in a given mixture using $K_2Cr_2O_7$ solution iv. Estimation of Fe(III) and Cr(VI) in a given mixture using $K_2Cr_2O_7$ solution v. Estimation of Fe(II) and Mn(II) in a given mixture using $KMnO_4$ solution vi. Estimation of Fe(III) and Ca(II) in a given mixture using $KMnO_4$ solution
CHEMISTRY-UG PAPER-CHEMHT-7 (Theory) Sem-III	Organic-III	Upon completion of the course, students will be able to learn: • **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 antihydroxylation, 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; dissolving metal reduction of alkenes; interconversion of E - and Z - alkenes; contrathermodynamic isomerization of internal alkenes. • **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, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity; interconversion of terminal and non-terminal alkynes
		Upon completion of the course, students will be able to learn: • **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. • **Nucleophilic aromatic substitution:** addition-elimination mechanism and evidences in favour of it; S_NAr mechanism; cine substitution (benzyne mechanism), structure of benzyne.
		Upon completion of the course, students will be able to learn: • **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, cyanohydrins 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 and Corey-Chaykovsky reaction; Rupe rearrangement, oxidations and reductions: Clemmensen, WolffKishner, $LiAlH_4$, $NaBH_4$, MPV, Oppenauer, Bouveault-Blanc, acyloin condensation; oxidation of alcohols with PDC and PCC; periodic acid and lead tetraacetate oxidation of 1,2-diols. **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, SeO_2 (Riley) oxidation; condensations (mechanism with evidence): Aldol, 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, aza-enolates and silyl enol ethers) in connection with alkylation, acylation and aldol type reaction. **Elementary ideas of Green Chemistry:** principles of green chemistry; planning of green synthesis; common organic reactions and their counterparts: reactions: Aldol, Friedel-Crafts, Michael, Knoevenagel, Cannizzaro, benzoin condensation and Dieckmann condensation. **Nucleophilic addition to α,β-unsaturated carbonyl system:** general principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction), Stetter reaction, Robinson annulations. **Substitution at sp^2 carbon (C=O system):** mechanism (with evidence): $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (in connection to acid and ester); acid derivatives
		Upon completion of the course, students will be able to learn: • Grignard reagent; Organolithiums; Gilman cuprates: preparation and reactions (mechanism with evidence); • addition of Grignard and organolithium to carbonyl compounds; substitution on -COX; directed ortho metalation of arenes using organolithiums, conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behavior of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; Blaise reaction; concept of umpolung and base-nucleophile dichotomy in case of organometallic reagents

CHEMISTRY-UG PAPER-CHEMHP-7 (Practical) Sem-III	Organic-III	Upon completion of the course, students will be able to learn: **Qualitative Analysis of Single Solid Organic Compounds:** 1. Detection of special elements (N, S, Cl, Br) by Lassaigne's test 2. Solubility and classification 3. Detection of the following functional groups by systematic chemical tests: 4. Aromatic amino, aromatic nitro, amido, phenolic hydroxyl , the carboxylic acid, carbonyl ; only one test for each functional group is to be reported. 5. Melting point of the given compound 6. Preparation, purification and melting point determination of a crystalline derivative of the given compound 7. Identification of the compound through a literature survey.
CHEMISTRY-UG PAPER-CHEMHS – 1A (Theory) Sem-III	IT skills for Chemist	Upon completion of the course, students will be able to learn: i. 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. ii. Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities. iii. Uncertainty in measurement: 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). iv. 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). v. 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). vi. Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).
		Upon completion of the course, students will be able to learn: Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. 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).
		Upon completion of the course, students will be able to learn: i. Introductory writing activities: Introduction to word processor and structure drawing (ChemSketch) software. Incorporating chemical structures, chemical equations, and expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents. ii. 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 a 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. iii. Numeric modelling: Simulation of pH metric titration curves. Excel functions LINEST and Least Squares. Numerical curve fitting, linear regression (rate constants from concentration-time data, molar extinction coefficients from absorbance data), numerical differentiation (e.g. handling data from potentiometric and pH metric titrations, pKa of weak acid), integration (e.g. entropy/enthalpy change from heat capacity data). iv. Statistical analysis: Gaussian distribution and Errors in measurements and their effect on data sets. Descriptive statistics using Excel. Statistical significance testing: The t-test. The F test. v. Presentation: Presentation graphics
CHEMISTRY-UG PAPER-CHEMHS-1B (Theory) Sem-III	Basic Analytical Chemistry	Upon completion of the course, students will be able to learn: Strategies of Analytical Chemistry and its interdisciplinary applicability. Protocol of sampling. Variability and validity of analytical measurements. Presentation of experimental data and results, from the point of view of significant figures
		Upon completion of the course, students will be able to learn: Complexometric titrations, Chelation, Chelating agents, use of indicators. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration. **Soil Analysis** Composition, pH of soil samples, estimation of calcium and magnesium content
		Upon completion of the course, students will be able to learn: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. Determination of pH, acidity and alkalinity of a water sample. Determination of Biological Oxygen Demand (BOD).
		Upon completion of the course, students will be able to learn: Nutritional value of foods, idea about food processing and food preservations and adulteration. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. Analysis of preservatives and colouring matter
		Upon completion of the course, students will be able to learn: Definition, general introduction on principles of chromatography, Paper chromatography, TLC etc. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}). To compare paint samples by TLC method
		Upon completion of the course, students will be able to learn: Column, ion-exchange chromatography etc. 2. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).
		Upon completion of the course, students will be able to learn: Major and minor constituents and their function

		Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration
		Upon completion of the course, students will be able to learn: study the use of phenolphthalein in trap cases. To analyse arson accelerants. To carry out analysis of gasoline
		Upon completion of the course, students will be able to learn: Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks
Chemistry UG (CBCS) Semester-IV		
CHEMISTRY-UG PAPER-CHEMHT-8 (Theory) Sem-IV	Physical Chemistry – III	Upon completion of the course, students will be able to learn: Colligative properties: Vapour pressure of solution; Ideal solutions, ideally dilute solutions and colligative properties; Raoult's law; Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) Osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution; Abnormal colligative properties. Phase rule: Definitions of phase, component and degrees of freedom; Phase rule and its derivations; Definition of phase diagram; Phase diagram for water, CO_2, Sulphur. First order phase transition and Clapeyron equation; Clausius-Clapeyron equation - derivation and use; Liquid vapour equilibrium for two component systems; Phenol-water system. Three component systems, water-chloroform-acetic acid system, triangular plots. 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.
		Upon completion of the course, students will be able to learn: Ionic equilibria: Chemical potential of an ion in solution; Activity and activity coefficients of ions in solution; Debye-Huckel limiting law-brief qualitative description of the postulates involved, qualitative idea of the model, the equation (without derivation) for ion-ion atmosphere interaction potential. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law; Derivation of mean ionic activity coefficient from the expression of ion-atmosphere interaction potential; Applications of the equation and its limitations. 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 halfcells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii)

		equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes. 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). Dipole moment and polarizability: Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules; Clausius-Mosotti equation and Debye equation (both without derivation) and their application; Determination of dipole moments.
		Upon completion of the course, students will be able to learn: Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component; Rigid rotator model of rotation of diatomic molecule; Schrödinger equation, transformation to spherical polar coordinates; Separation of variables. 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). LCAO and HF-SCF: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+; Bonding and antibonding orbitals; Qualitative extension to H_2; Comparison of LCAO-MO and VB treatments of H_2 and their limitations; Hartree-Fock method development, SCF and configuration interaction
CHEMISTRY-UG PAPER-CHEMHP-8 (Practical) Sem-IV	Physical – III	Upon completion of the course, students will be able to learn: i. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator). ii. Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$ solution. iii. Determination of Ksp for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution. iv. Effect of ionic strength on the rate of Persulphate –Iodide reaction. v. Study of phenol-water phase diagram. vi. pH-metric titration of acid (mono-and di-basic) against strong base.
CHEMISTRY-UG PAPER-CHEMHT-9 (Theory) Sem-IV	Inorganic Chemistry – III	Upon completion of the course, students will be able to learn: Atomic nucleus – nuclear stability, n/p ratio and different modes of decay, mass defect, packing fraction and nuclear binding energy. Nuclear forces: Meson exchange theory, elementary idea of nuclear shell model and magic numbers. Fission, fusion and spallation reactions, artificial radioactivity, super heavy elements and their IUPAC nomenclature. Moderators, slow and fast neutrons, Applications of radio-isotopes in: determination of structures, establishment of reaction mechanisms and radio-carbon dating, hazards of radiation and safety measures
		Upon completion of the course, students will be able to learn: Diagonal relationship (Li-Mg; B-Si) and anomalous behaviour of first member of each group, Allotropy and catenation (examples of C, P and S compounds). Study of the following compounds with emphasis on preparation, properties, structure and bonding: Berylium hydrides and halides; diborane; borazine; boron nitride, boric acid, borax, fluorocarbons (with environmental effect); oxides and oxyacids of nitrogen, phosphorous, sulphur and chlorine; Peroxo acids of sulphur; tetrasulphurtrtranitride; interhalogens, pseudohalogens,

		polyhalides, fluorides and oxides of xenon. Noble gas clathrates; basic properties of iodine. Synthesis, structural aspects and applications of silicones and phosphazines;
		Upon completion of the course, students will be able to learn: Idea about double salts and complex salts, Werner's theory, EAN rule, classification of ligands and their binding modes, IUPAC nomenclature of coordination compounds (up to two metal centres), overall and stepwise stability constants, chelates, innermetallic complexes, Stereochemistry and isomerism (constitutional and stereo) of complexes with coordination no. 4 and 6
CHEMISTRY-UG PAPER-CHEMHP-9 (Practical) Sem-IV	Inorganic - III	Upon completion of the course, students will be able to learn: **A. Complexometric Titration :** i. Estimation of Hardness of water ii. Estimation of Ca(II) and Mg(II) in a mixture iii. Estimation of Zn(II) and Mg(II) in a mixture **B. Inorganic Preparation :** i. Mohr's salt ii. Potassium tris(oxalato)chromate(III) trihydrate iii. Tetraamminecarbonatocobalt(III) nitrate iv. Potassiumbis(oxalato)cuprate(II) dihydrate v. Tris(ethylenediamine)nickel(II) chloride
CHEMISTRY-UG PAPER-CHEMHT-10 (Theory) Sem-IV	Organic Chemistry – IV	Upon completion of the course, students will be able to learn: **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. **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. **Alkylnitrile and isonitrile:** preparation and reaction (with mechanism): Thorpe nitrile condensation, von Richter reaction. **Diazonium salts and their related compounds:** reactions (with mechanism) involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp-Klingermann.
		Upon completion of the course, students will be able to learn: **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. **Rearrangement to electron-deficient nitrogen:** rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann. **Rearrangement to electron-deficient oxygen:** Baeyer-Villiger oxidation, cumene hydroperoxide-phenol rearrangement and Dakin reaction. **Aromatic rearrangements:** Migration from oxygen to ring carbon: Fries rearrangement and Claisen rearrangement. **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. **Rearrangement reactions by green approach:** Fries rearrangement, Claisen rearrangement, Beckmann rearrangement, Baeyer-Villiger oxidation.
		Upon completion of the course, students will be able to learn: **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 (1,6dicarbonyl); protection-deprotection strategy (alcohol, amine, carbonyl, acid). **Strategy of ring synthesis:** thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique. **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 stereogeniccentre: Felkin-Anh and Zimmermann-Traxler models
		Upon completion of the course, students will be able to learn: **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. **IR Spectroscopy:** introduction; modes of molecular vibrations (fundamental and non-fundamental); 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. **NMR Spectroscopy:** introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; equivalent and nonequivalent 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. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules.
CHEMISTRY-UG PAPER-CHEMHP-10	Organic-IV	Upon completion of the course, students will be able to learn: i. Estimation of glycine by Sörensen's formol method ii. Estimation of glucose by titration using Fehling's solution

(Practical) Sem-IV		iii. Estimation of sucrose by titration using Fehling's solution iv. Estimation of vitamin-C (reduced) v. Estimation of aromatic amine (aniline) by bromination (Bromate-Bromide) method vi. Estimation of phenol by bromination (Bromate-Bromide) method vii. Estimation of formaldehyde (Formalin) viii. Estimation of acetic acid in commercial vinegar ix. Estimation of urea (hypobromite method) x. Estimation of saponification value of oil/fat/ester
CHEMISTRY-UG PAPER-CHEMHS – 2A (Theory) Sem-IV	Pharmaceutical Chemistry	Upon completion of the course, students will be able to learn: 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).
		Upon completion of the course, students will be able to learn: 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.
		Upon completion of the course, students will be able to learn: Preparation of Aspirin and its analysis. Preparation of magnesium bisilicate (Antacid).
CHEMISTRY-UG PAPER-CHEMHS - 2B (Theory) Sem-IV	Analytical-Clinical Biochemistry	Upon completion of the course, students will be able to learn: Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysachharides. Proteins: Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins. Enzymes: Nomenclature, Characteristics (mention of Ribozymes), and Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry. Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins. Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.
		Upon completion of the course, students will be able to learn: Blood: Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin. Urine: Sampling and preservation, composition and estimation of constituents of normal and pathological urine
		Upon completion of the course, students will be able to learn: Identification and estimation of the following:

		i. Carbohydrates – qualitative and quantitative. ii. Lipids – qualitative. iii. Determination of the iodine number of oil. iv. Determination of the saponification number of oil. v. Determination of cholesterol using Liebermann- Burchard reaction. vi. Proteins – qualitative. vii. Isolation of protein. viii. Determination of protein by the Biuret reaction. ix. Determination of nucleic acids
		Chemistry UG (CBCS) Semester-V
CHEMISTRY-UG PAPER-CHEMHT-11 (Theory) Sem-V	Inorganic Chemistry – IV	Upon completion of the course, students will be able to learn: Structure and bonding of coordination compounds on the basis of V.B.Theory and its limitations. Elementary idea about CFT, splitting of d^n configuration in ML_4 to ML_6 and ML_8 systems, factors affecting , measurement of $_o$, spectrochemical series of ligands, CFSE in weak and strong fields, OSSE, High spin and low spin complexes, spin isomerism, tetragonal distortion, Jahn Teller theorem and applications, achievements and limitations of CFT, nephalauxetic effect, stabilisation of unusually high and low oxidation states of 3d series elements, MOT (elementary idea), σ and π bonding in octahedral complexes (a pictorial approach). Colour and electronic spectra of complexes: selection rules for electronic transitions, d-d transition, charge transfer transition (qualitative idea), L-S coupling and R-S ground state term for atomic no. up to 30, qualitative ORGEL diagram for $3d^1$ – $3d^9$ ions with appropriate symbols for the energy levels
		Upon completion of the course, students will be able to learn: Classification of magnetic substances, Origin of para magnetic moments, temperature dependence of para magnetism – Curie and Curie-Weiss law, TIP, magnetic susceptibility and its measurement (Gouy method), diamagnetic correction, effective magnetic moment, spin only moment for 3d metals, Orbital contribution to magnetic moment, spin-orbit coupling, quenching of orbital contribution, Sub-normal magnetic moments and antiferromagnetic interactions (elementary idea with examples).
		Upon completion of the course, students will be able to learn: **d-block elements:** Characteristic properties, Comparison among the elements of 3d series with reference to electronic configuration, oxidation states and E^0 values; General comparison between 3d, 4d and 5d series elements in term of electronic configuration, oxidation states, atomization energy, magnetic properties and coordination chemistry. **f-block elements:** Comparison between d and f-block elements; Electronic configuration, oxidation states, variation of magnetic properties (Ln^{3+}), atomic and ionic(3+) radii of lanthanoids; consequences of lanthanide contraction, separation of lanthanides by ion exchange and solvent extraction methods; comparison between lanthanoids and actinoids.
		Upon completion of the course, students will be able to learn: Introduction to inorganic reaction mechanisms, substitution reactions in square planar complexes; *trans*-effect - theories and applications; lability and inertness in octahedral complexes towards substitution reactions. Elementary concept of *cis*-effect.
CHEMISTRY-UG PAPER-CHEMHP-11	Inorganic - IV	Upon completion of the course, students will be able to learn: **A. Quantitative:** i. Estimation of available chlorine in bleaching powder using iodometry

(Practical) Sem-V		ii. Estimation of available oxygen in pyrolusite using permanganometry iii. Estimation of Cu in brass using iodometry iv. Estimation of Fe in cement using permanganometry v. Estimation of chloride gravimetrically vi. Estimation of Ni(II) using DMG gravimetrically **B. Experiment:** i. Paper chromatographic separation of Ni(II) and Co(II) ii. Measurement of 10Dq by spectrophotometric method iii. Preparation of Mn(acac)3 and determination of its λmaxcolorimetrically
CHEMISTRY-UG PAPER-CHEMHT-12 (Theory) Sem-V	Physical Chemistry – IV	Upon completion of the course, students will be able to learn: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. 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, concept of group frequencies; Diatomic vibrating rotator, P, Q, R branches.\ Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Vibrational Raman spectra, Stokes and anti-Stokes lines. Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra. Electron Spin Resonance (ESR) spectroscopy: Its principle, ESR of simple radicals.
		Upon completion of the course, students will be able to learn: Lambert-Beer's law: Characteristics of electromagnetic radiation, LambertBeer'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. 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, Jablonskii diagram. Rate of Photochemical processes: Photochemical equilibrium and the differential rate of photochemical reactions, Photostationary state; HI decomposition, H_2-Br_2 reaction, dimerisation of anthracene; photosensitised reactions, quenching; Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.
		Upon completion of the course, students will be able to learn: 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 surface; Vapour pressure over curved surface; Temperature dependence of surface tension. 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. 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
CHEMISTRY-UG PAPER-CHEMHP-12 (Practical) Sem-V	Physical-IV	Upon completion of the course, students will be able to learn: i. Determination of surface tension of a liquid using a Stalagmometer. ii. Determination of CMC from surface tension measurements. iii. Verification of Beer and Lambert's Law for $KMnO_4$and $K_2Cr_2O_7$solution. iv. Study of kinetics of $K_2S_2O_8$+ KI reaction, spectrophotometrically. v. Determination of pH of unknown buffer, spectrophotometrically. vi. Spectrophotometric determination of CMC.
CHEMISTRY-UG PAPER- CHEMHTDSE-1A (Theory) Sem-V	Polymer Chemistry	Upon completion of the course, students will be able to learn: Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.
		Upon completion of the course, students will be able to learn: Criteria for synthetic polymer formation, classification of polymerization processes, elationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.
		Upon completion of the course, students will be able to learn: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations.
		Upon completion of the course, students will be able to learn: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.
		Upon completion of the course, students will be able to learn: Structure Property relationships.
		Upon completion of the course, students will be able to learn: (M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.
		Upon completion of the course, students will be able to learn: Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).
		Upon completion of the course, students will be able to learn: Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Lower and Upper critical solution temperatures.
		Upon completion of the course, students will be able to learn: (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, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, Polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers
CHEMISTRY-UG PAPER- CHEMHPDSE-1A (Practical) Sem-V	Polymer Chemistry	Upon completion of the course, students will be able to learn: 1. Polymer Synthesis a. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA). b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bisisobutylonitrile (AIBN) c. Preparation of nylon 66/6. 2. Polymer characterization a. Determination of molecular weight by viscometry: i. Polyacrylamide-aq.$NaNO_2$ solution ii. Poly vinyl proplylidine (PVP) in water b. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer. c. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group). d. Determination of hydroxyl number of a polymer using colorimetric method. 3. Polymer analysis a. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
CHEMISTRY-UG PAPER- CHEMHTDSE-1B (Theory) Sem-V	Inorganic Materials of Industrial Importance	
		Upon completion of the course, students will be able to learn: i. Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass. ii. Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre. iii. Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.
		Upon completion of the course, students will be able to learn: Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.
		Upon completion of the course, students will be able to learn: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Pigments, toners and laker pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Water and Oil paints, additives, Metallic coatings
		Upon completion of the course, students will be able to learn: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery,

		Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.
		Upon completion of the course, students will be able to learn: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation).. Composition and properties of different types of steels.
		Upon completion of the course, students will be able to learn: General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.
		Upon completion of the course, students will be able to learn: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.
CHEMISTRY-UG PAPER- CHEMHPDSE-1B (Practical) Sem-V	Inorganic Materials of Industrial Importance	Upon completion of the course, students will be able to learn: 1. Determination of free acidity in ammonium sulphate fertilizer. 2. Estimation of Calcium in Calcium ammonium nitrate fertilizer. 3. Estimation of phosphoric acid in superphosphate fertilizer. 4. Electroless metallic coatings on ceramic and plastic material. 5. Determination of composition of dolomite (by complexometric titration). 6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples. 7. Analysis of Cement. 8. Preparation of pigment (zinc oxide).
CHEMISTRY-UG PAPER- CHEMHTDSE-2A (Theory) Sem-V	Analytical Methods in Chemistry	Upon completion of the course, students will be able to learn: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals
		Upon completion of the course, students will be able to learn: i. Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. ii. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; iii. 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. iv. Infrared Spectrometry: 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. v. Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, and detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples
		Upon completion of the course, students will be able to learn: Theory of thermogravimetry (TG), instrumentation. Composition determination of Ca and Mg from their mixture.

		Upon completion of the course, students will be able to learn: 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
		Upon completion of the course, students will be able to learn: i. Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. ii. Technique of extraction: batch, continuous and counter current extractions. iii. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. iv. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. v. Development of chromatograms: frontal, elution and displacement methods. vi. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC. vii. Separation and analysis using GC and HPLC (dye and pesticide analysis) viii. Role of computers in instrumental methods of analysis
CHEMISTRY-UG PAPER-CHEMHPDSE-2A (Practical) Sem-V	Analytical Methods in Chemistry	Upon completion of the course, students will be able to learn: 1. Separation Techniques – Chromatography i. Separation of mixtures Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by Paper chromatography. Reporting the RF values. ii. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their RF values. iii. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC 2. Solvent Extractions 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. 3. Ion exchange: Determination of exchange capacity of cation exchange resins and anion exchange resins. 4. Spectrophotometry i. Determination of pKa values of indicator using spectrophotometry ii. Analysis of soil: a. Determination of pH of soil. b. Total soluble salt c. Estimation of calcium / magnesium / phosphate / nitrate.
CHEMISTRY-UG PAPER-	Instrumental Methods of	Upon completion of the course, students will be able to learn: Spectroscopic methods covered in detail in the core chemistry syllabus: Classification of analytical methods and the types of instrumental methods.

CHEMHTDSE-2B (Theory) Sem-V	Chemical Analysis	Consideration of electromagnetic radiation
		Upon completion of the course, students will be able to learn: Infrared spectroscopy: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection. UV-Visible/ Near IR – emission, absorption and fluorescence Excitation sources (lasers, time resolution), wavelength dispersion (grating, prism, filter). Resolution, detection of signal (photocells, photomultipliers, diode arrays), sensitivity and S/N, Single and Double Beam instruments, Interpretation (quantification, mixtures).
		Upon completion of the course, students will be able to learn: Principles of Gas chromatography, liquid chromatography, supercritical fluid chromatography, Importance of column chromatographic technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field) Detection of different samples, single and coupled / hyphenated detector
		Upon completion of the course, students will be able to learn: spectrometry (electrical discharges). Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and atomisation (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).
		Upon completion of the course, students will be able to learn: Principle, Instrumentation, Factors affecting chemical shift, Spin- coupling, Applications.
		Upon completion of the course, students will be able to learn: Potentiometry & Voltammetry
		Upon completion of the course, students will be able to learn: Basic idea of X-ray analysis and electron spectroscopy (surface analysis
CHEMISTRY-UG PAPER- CHEMHPDSE-2B (Practical) Sem-V	Instrumental Methods of Chemical Analysis	Upon completion of the course, students will be able to learn understand: 1. Safety Practices in the Chemistry Laboratory 2. Determination of Cobalt and Nickel from mixture 3. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water) 4. IR Absorption Spectra (Study of Aldehydes and Ketones) 5. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption 6. Potentiometric Titration of a Chloride - Iodide Mixture 7. Analysis of illicit drugs. 8.Detection in the field and confirmation in the laboratory of flammable accelerants or explosives 9. Detection of steroids.

		10. Detection of pollutants from wastes. 11. Fibre analysis 12. Titration curve of amino acid. 13. Determination of the void volume of a gel filtration column. 14. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride) 15. Separation of Carbohydrates by HPLC 16. Determination of Caffeine in Beverages by HPLC 17. Cyclic Voltammetry of the Ferrocyanide/ Ferricyanide Couple 18. Nuclear Magnetic Resonance 19. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids. 20. Use of "presumptive tests" for anthrax or cocaine 21. Collection, preservation, and control of blood evidence being used for DNA testing 22. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome) 23. Use of sequencing for the analysis of mitochondrial DNA
CHEMISTRY-UG PAPER-CHEMHTDSE-2C (Theory) Sem-V	Green Chemistry	Upon completion of the course, students will be able to learn: What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry
		Upon completion of the course, students will be able to learn: Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products , Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy. Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis. Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation. Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes
		Upon completion of the course, students will be able to learn: Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)

		Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine) Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of Environmentally safe marine antifoulant. Right fit pigment: synthetic azopigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting
		Upon completion of the course, students will be able to learn: Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.
CHEMISTRY-UG PAPER-CHEMHPDSE-2C (Practical) Sem-V	Green Chemistry	Upon completion of the course, students will be able to learn: Safer starting materials: Preparation and characterization of nanoparticles of gold using tea leaves. Using renewable resources: Preparation of biodiesel from vegetable/ waste cooking oil. Avoiding waste: Principle of atom economy. Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry. Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy. Use of enzymes as catalysts: Benzoin condensation using Thiamine cation (anchored enzyme) as a catalyst instead of cyanide. Alternative Green solvents: Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice. Mechanochemical solvent free synthesis of azomethines Alternative sources of energy: Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II). Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
CHEMISTRY-UG PAPER-CHEMHT-13 (Theory) Sem-V	Inorganic - V	Upon completion of the course, students will be able to learn: Symmetry as a universal theme, concept of symmetry elements and operations (with examples); symmetry properties of atomic orbitals (s, p and d); concept of point groups, identification of molecular point groups in some simple molecules and ions; applications of symmetry for polarity and chirality.
		Upon completion of the course, students will be able to learn: Essential elements oflife, Role of metal ions in living systems- a brief review, Elementary idea about proteins, enzymes and ionophores; Structure of ATP, Na^+ ion pump and transport of Na^+ and K^+ across cell membrane; active site structures and bio-functions of haemoglobin, myoglobin, carboxy peptidase A,

		carbonic anhydrase B, cytochrome c, ferredoxins and chlorophyll; biological nitrogen fixation; toxic metals (Pb, Cd and Hg) and their effects, Wilson disease, chelation therapy; platinum and gold complexes as drugs (examples only).
		Upon completion of the course, students will be able to learn: Definition, Classification of organometallic compounds, hapticity of ligands, nomenclature, 16- electron & 18-electron rule and its applications; preparation and structure of mono- and bi-nuclear carbonyls of 3d series, synergic effect of CO and use of IR data to explain extent of back bonding; General methods of preparation of metal-carbon σ-bonded complexes, Zeise's salt, Metal-carbon multiple bonding; Preparation, structures, properties and reactions of ferrocene; elementary idea about oxidative addition, reductive elimination, insertion reactions; Study of the following catalytic processes: alkene hydrogenation (Wilkinson's catalyst), hydroformylation, Wacker process, Synthetic gasoline (Fischer Tropsch reaction) and Olefin polymerization reaction (Ziegler-Natta catalyst)
CHEMISTRY-UG PAPER-CHEMHP-13 (Practical) Sem-V	Inorganic - V	Upon completion of the course, students will be able to learn: **Qualitative semi-micro analysis** Qualitative semi-micro analysis of mixtures containing four radicals (excluding oxide and carbonate).
	Chemistry UG (CBCS) Semester-VI	
CHEMISTRY-UG PAPER-CHEMHT-14 (Theory) Sem-VI	Organic Chemistry – V	Upon completion of the course, students will be able to learn: **Polynuclear hydrocarbons and their derivatives:** synthetic methods include Haworth, Bardhan-Sengupta, Bogert-Cook and other useful syntheses (with mechanistic details); fixation of double bonds and Fries rule; reactions (with mechanism) of naphthalene, anthracene, phenanthrene and their derivatives. **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.
		Upon completion of the course, students will be able to learn: **Alicyclic compounds:** concept of I-strain; conformational analysis: cyclohexane, mono and disubstituted cyclohexane; symmetry properties and optical activity; topomerisation; ring-size and ease of cyclisation; conformation & reactivity in cyclohexane system: consideration of steric and stereoelectronic requirements; elimination (E2, E1), nucleophilic substitution (S_N1, S_N2, S_Ni, NGP), merged substitution-elimination; rearrangements; oxidation of cyclohexanol, esterification, saponification, lactonisation, epoxidation, pyrolytic syn elimination and fragmentation reactions.
		Upon completion of the course, students will be able to learn: **Mechanism, stereochemistry, regioselectivity in case of Electrocyclic**

		reactions: FMO approach involving 4π- and 6π-electrons (thermal and photochemical) and corresponding cycloreversion reactions. **Cycloaddition reactions:** FMO approach, Diels-Alder reaction, photochemical [2+2] cycloadditions. **Sigmatropic reactions:** FMO approach, sigmatropic shifts and their order; [1,3]- and [1,5]-H shifts an [3,3]-shifts with reference to Claisen and Cope rearrangements.
		Upon completion of the course, students will be able to learn: **Monosaccharides:** Aldoses up to 6 carbons; structure of D-glucose &Dfructose (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; end-group-interchange of aldoses; acetonide (isopropylidene) and benzylidene protections; ring-size determination; Fischer's proof of configuration of (+)-glucose. **Disaccharides:** Glycosidic linkages, concept of glycosidic bond formation by glycosyl donor-acceptor; structure of sucrose, inversion of cane sugar. **Polysaccharides:** starch (structure and its use as an indicator in titrimetric analysis).
		Upon completion of the course, students will be able to learn: **Amino acids:** synthesis with mechanistic details: Strecker, Gabriel, acetamido malonic ester, azlactone, Bücherer hydantoin synthesis,
CHEMISTRY-UG PAPER-CHEMHP-14 (Practical) Sem-VI	Organic-V	Upon completion of the course, students will be able to learn: 1. TLC separation of a mixture containing 2/3 amino acids 2. TLC separation of a mixture of dyes (fluorescein and methylene blue) synthesis involving diketopiperazine; isoelectric point, zwitterions; electrophoresis, reaction (with mechanism): ninhydrin reaction, Dakin- West reaction; resolution of racemic amino acids. **Peptides:** peptide linkage and its geometry; syntheses (with mechanistic details) of peptides using N-protection & C-protection, solid-phase (Merrifield) synthesis; peptide sequence: C-terminal and N-terminal unit determination (Edman, Sanger & 'dansyl' methods); partial hydrolysis; specific cleavage (enzymatic) of peptides: use of CNBr. **Nucleic acids:** pyrimidine and purine bases (only structure & nomenclature); nucleosides and nucleotides corresponding to DNA and RNA; mechanism for acid catalysed hydrolysis of nucleosides (both pyrimidine and purine types); comparison of alkaline hydrolysis of DNA and RNA; elementary idea of double helical structure of DNA (WatsonCrick model); complimentary base–pairing in DNA 3. Column chromatographic separation of leaf pigments from spinach leaves 4. Column chromatographic separation of mixture of dyes 5. Paper chromatographic separation of a mixture containing 2/3 amino acids 6. Paper chromatographic separation of a mixture containing 2/3 sugars **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:
CHEMISTRY-UG PAPER- CHEMHTDSE-3 (Theory) Sem-VI	Advanced Physical Chemistry	Upon completion of the course, students will be able to learn: Bravais Lattice and Laws of Crystallography: Types of solid, Bragg's law of diffraction; Laws of crystallography (Haüy'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). Crystal planes: Distance between consecutive planes [cubic, tetragonal and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of dhkl; Relation between molar mass and unit cell dimension for cubic system; Bragg's law (derivation). Determination of crystal structure: Powder method; Structure of NaCl and KCl crystals.
		Upon completion of the course, students will be able to learn: Configuration: Macrostates, microstates and configuration; variation of W with E; equilibrium configuration. Boltzmann distribution: Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution; Partition function, concept of ensemble -canonical ensemble and grand canonical ensembles. Partition function: molecular partition function and thermodynamic properties.
		Upon completion of the course, students will be able to learn: 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. 3rd law: Absolute entropy, Plank's law, Calculation of entropy, Nernst heat theorem. 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.
CHEMISTRY-UG PAPER- CHEMHPDSE-3 (Practical) Sem-VI	Advanced Physical Chemistry	Upon completion of the course, students will be able to learn: **Computer Programming based on numerical methods for:** i. Roots of equations: (e.g. volume of van der Waals gas and comparison with an ideal gas, pH of a weak acid). ii. Numerical differentiation (e.g., change in pressure for a small change in volume of a van der Waals gas, potentiometric titrations). iii. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values. iv. Simple exercises using molecular visualization software

CHEMISTRY-UG PAPER- CHEMHTDSE-4 (Theory) Sem-VI	Project Work	Upon completing the course, students can learn to do a Project Work.
CHEMISTRY-UG PAPER- CHEMHPDSE-4 (Practical) Sem-VI	Project Work	Upon completion of the course, students will be able to learn to make a PowerPoint presentation and deliver a short oral presentation.

B. Sc. (General) with Chemistry

Program Specific Outcomes (PSO):

(a) Learning the fundamentals of the subject, such as theories and methodologies, ideas, and general principles.

(b) Perform experiments and interpret the results of observation.

(c) Understanding chemical formulas and structures, as well as answering numerical difficulties.

(d) Understanding of proper laboratory practice and safety.

(e) Attract students from different backgrounds.

Class/ Paper/ Semester	Title	Course Outcome (CO)
	Chemistry UG (CBCS) Semester-I	
CHEMISTRY-UG PAPER-CHEMGT-1 (Theory) Sem-I	Inorganic Chemistry - I	Upon completion of the course, students will be able to learn: Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, Aufbau principle and its limitations.
		Upon completion of the course, students will be able to learn: Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases in the periodic table. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and groupwise variation of above properties in respect of s- and p- block elements
		Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.
		Upon completion of the course, students will be able to learn: Balancing of equations by oxidation number and ion-electron method, Standard electrode potential, formal potential, redox indicator and redox titrations. Upon completion of the course, students will be able to learn:

	Organic Chemistry – I	Upon completion of the course, students will be able to learn: **Electronic displacements:** Inductive effect, resonance and hyperconjugation; cleavage of bonds: homolytic and heterolytic; structure of organic molecules on the basis of VBT; nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals
		Upon completion of the course, students will be able to learn: Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; elements of symmetry (plane and centre); interconversion of Fischer and Newman representations; enantiomerism and diastereomerism, meso compounds; threo and erythro, D and L, cis and trans nomenclature; CIP Rules: R/S (upto 2 chiral carbon atoms) and E/Z nomenclature
		Upon completion of the course, students will be able to learn: Nucleophilic substitutions: S_N1 and S_N2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations; elimination vs substitution
		Upon completion of the course, students will be able to learn: Functional group approach for the different reactions (preparations & reactions) in context to their structures
CHEMISTRY-UG PAPER-CHEMGP-1 (Practical) Sem-I	Inorganic Chemistry - I	Upon completion of the course, students will be able to learn: 1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. 2. Estimation of oxalic acid by titrating it with $KMnO_4$. 3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$. 4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$. 5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
	Organic Chemistry – I	Upon completion of the course, students will be able to learn: Qualitative Analysis of Single Solid Organic Compound(s) 1. Detection of special elements (N, Cl, and S) in organic compounds. 2. Solubility and Classification 3. Detection of functional groups
Chemistry UG (CBCS) Semester-II		
CHEMISTRY-UG PAPER-CHEMGT-2 (Theory) Sem-II	Physical Chemistry – I	Upon completion of the course, students will be able to learn: a. 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); Rate of effusion b. Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases c. 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; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states d. Viscosity of gases and effect of temperature and pressure on the coefficient of

		viscosity (qualitative treatment only)
		Upon completion of the course, students will be able to learn: Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)
		Upon completion of the course, students will be able to learn: Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl treatment only); Defects in crystals; Glasses and liquid crystals.
		Upon completion of the course, students will be able to learn: Introduction of qualitative rate law, order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions Temperature dependence of rate constant; Arrhenius equation, the energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)
	Inorganic Chemistry - II	Upon completion of the course, students will be able to learn: Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions based on VSEPR and hybridization with suitable examples from s and p block elements of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, the nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods. (including the idea of s- p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.
		Upon completion of the course, students will be able to learn: a. Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the different groups of elements:
CHEMISTRY-UG	Physical	Upon completion of the course, students will be able to learn:

PAPER-CHEMGP-2 (Practical) Sem-II	Chemistry – I	1. Surface tension measurement (use of organic solvents excluded) a. Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer b. Study of the variation of surface tension of a detergent solution with the concentration 2. Viscosity measurement (use of organic solvents excluded) a. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer b. Study of the variation of viscosity of an aqueous solution with concentration of solute 3. Study the kinetics of the following reactions a. Initial rate method: Iodide-persulphate reaction b. Integrated rate method: i. Acid hydrolysis of methyl acetate with hydrochloric acid Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate
	Inorganic Chemistry – II	Upon completion of the course, students will be able to learn: Qualitative semi-micro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions. Acid Radicals: Cl^-, Br^-, I^-, NO_2^-, NO_3^-, S^{2-}, SO_4^{2-}, BO_3^{3-}, H_3BO_3. Basic Radicals: Na^+, K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cr^{3+}, Mn^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, NH_4^+.
		Chemistry UG (CBCS) Semester-III
CHEMISTRY-UG PAPER-CHEMGT-3 (Theory) Sem-III	Physical Chemistry - II	Upon completion of the course, students will be able to learn: a. 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; the relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases b. 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 the enthalpy of reactions; Adiabatic flame temperature; explosion temperature c. Statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine, refrigerator and efficiency; Entropy change of systems and surroundings for various processes and transformations; Auxiliary state functions (G and A) and Criteria for spontaneity and equilibrium.
		Upon completion of the course, students will be able to learn: Thermodynamic conditions for equilibrium, degree of advancement; Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of KP, KC and KX and relation among them; van't Hoff's reaction isotherm, isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle
		Upon completion of the course, students will be able to learn: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water; Ionization

		of weak acids and bases, pH scale, common ion effect; Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts; Buffer solutions; Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.
	Organic Chemistry - II	Upon completion of the course, students will be able to learn: Benzene: Preparation: from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: electrophilic substitution (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination), sulphonation and Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene); side-chain oxidation of alkyl benzenes (up to 4 carbons on benzene).
		Upon completion of the course, students will be able to learn: Introduction; Grignard reagents: Preparations (from alkyl and aryl halide); the concept of umpolung; Reformatsky reaction.
		Upon completion of the course, students will be able to learn: Preparation: (chloro-, bromo- and iodobenzene): from phenol, Sandmeyer reactions. Reactions (Chlorobenzene): nucleophilic aromatic substitution (replacement by –OH group) and effect of nitro substituent (activated nucleophilic substitution).
		Upon completion of the course, students will be able to learn: a. Alcohols: (up to 5 Carbons). Preparation: 1°-, 2°- and 3°- alcohols: using Grignard reagent, reduction of aldehydes, ketones, carboxylic acid and esters; Reactions: With sodium, HX (Lucas test), oxidation (alkaline $KMnO_4$, acidic dichromate, concentrated HNO_3); Oppenauer oxidation; b. Diols: Preparation (with OsO_4); pinacol- pinacolone rearrangement (with mechanism) (with symmetrical diols only). c. Phenols: Preparation: cumene hydroperoxide method, from diazonium salts; acidic nature of phenols; Reactions: electrophilic substitution: nitration and halogenations; Reimer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries rearrangement and Claisen rearrangement. d. Ethers: Preparation: Williamson's ether synthesis; Reaction: cleavage of ethers with HI
		Upon completion of the course, students will be able to learn: Aldehydes and Ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde): Preparation: from acid chlorides, from nitriles and Grignard reagents; general properties of aldehydes and ketones; aldol condensation (with mechanism); Cannizzaro reaction (with mechanism), Wittig reaction, benzoin condensation; Clemmensen reduction, Wolff-Kishner reduction and Meerwein-Pondorff-Verley (MPV) reduction
CHEMISTRY-UG PAPER-CHEMGP-3 (Practical) Sem-III	Physical Chemistry - II	Upon completion of the course, students will be able to learn: **Thermochemistry** 1. Determination of heat capacity of calorimeter for different volumes 2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide 3. Determination of enthalpy of ionization of acetic acid 4. Determination of enthalpy of hydration of copper sulphate **Ionic Equilibria** 1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter and compare it with the indicator

		method 2. Preparation of buffer solutions and finding the pH of an unknown buffer solution by colour matching method (using the following buffers) a. Sodium acetate-acetic acid b. Ammonium chloride-ammonium hydroxide 3. Study of the solubility of benzoic acid in water
	Organic Chemistry - II	Upon completion of the course, students will be able to learn: Identification of a pure organic compound Solid compounds: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid. Liquid Compounds: methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline,
Chemistry UG (CBCS) Semester-IV		
CHEMISTRY-UG PAPER-CHEMGT-4 (Theory) Sem-IV	Physical Chemistry – III	Upon completion of the course, students will be able to learn: deal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions; Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions; Distillation of solutions; Lever rule; Azeotropes, Critical solution temperature; effect of impurity on partial miscibility of liquids; Immiscibility of liquids-Principle of steam distillation; Nernst distribution law and its applications, solvent extraction
		Upon completion of the course, students will be able to learn: a. Phases, components and degrees of freedom of a system, criteria of phase equilibrium; Gibbs Phase Rule and its thermodynamic derivation; Derivation of Clausius – Clapeyron equation and its importance in phase equilibria; Phase diagrams of one-component systems (water and sulphur) and two-component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only)
		a. Conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Ostwald's dilution law; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations (acid-base) Transport Number and principles of Hittorf's and Moving-boundary method
		Upon completion of the course, students will be able to learn: 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; Electrochemical series; Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data Concentration cells with and without transference, liquid junction potential; pH determination using hydrogen electrode and quinhydrone; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)
	Inorganic	Upon completion of the course, students will be able to learn: a. General group trends with special reference to electronic configuration,

<table>
<tr><td rowspan="3"></td><td rowspan="3">Chemistry - III</td><td>variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.
b. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).</td></tr>
<tr><td>Upon completion of the course, students will be able to learn:
a. Werner’s coordination theory, Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. b. Drawbacks of VBT. IUPAC system of nomenclature.</td></tr>
<tr><td>Upon completion of the course, students will be able to learn:
a. Postulates of CFT, splitting of d-orbitals in octahedral and tetrahedral fields, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. b. Jahn-Teller distortion</td></tr>
<tr><td rowspan="2">CHEMISTRY-UG
PAPER-CHEMGP-4
(Practical)
Sem-IV</td><td>Physical Chemistry - III</td><td>Upon completion of the course, students will be able to learn:
1. Distribution Law
a. Study of the equilibrium by the distribution method
2. Conductance
a. Determination of dissociation constant of a weak acid (cell constant, equivalent conductance are also determined)
b. Perform the following conductometric titrations:
i. Strong acid vs. strong base
ii. Weak acid vs. strong base
3. Potentiometry
a. Perform the following potentiometric titrations:
i. Weak acid vs. strong base
ii. Potassium dichromate vs. Mohr's salt</td></tr>
<tr><td>Inorganic Chemistry – III</td><td>Upon completion of the course, students will be able to learn:
1. Complexometric estimation of (i) Mg^{2+} or (ii) Zn^{2+} using EDTA.
2. Preparation of any two of the following complexes:
a. tetraamminecarbonatocobalt (III) nitrate
b. tetraamminecopper(II) sulphate
c. potassium trioxalatochromate(III) trihydrate
d. potassium bisoxalatocuprate(II) trihydrate</td></tr>
<tr><td colspan="3"><u>Chemistry UG (CBCS) Semester-V</u></td></tr>
<tr><td>CHEMISTRY-UG
PAPER-CHEMGTDSE-1
(Theory)
Sem-V</td><td>Analytical and Environmental Chemistry</td><td>Upon completion of the course, students will be able to learn:
a. Gravimetric analysis: solubility product and common ion effect; requirements of gravimetry; gravimetric estimation of chloride, sulphate, lead, barium, nickel, copper and zinc.
b. Volumetric analysis: primary and secondary standard substances; principles of acid-base, oxidation–reduction and complexometric titrations; indicators: acid-base, redox and metal ion; principles of estimation of mixtures: $NaHCO_3$ and Na_2CO_3 (by acidimetry); iron, copper, manganese and chromium (by redox titration); zinc, aluminum, calcium and magnesium (by complexometric EDTA titration).
c. Chromatography: Chromatographic methods of analysis: column</td></tr>
</table>

		chromatography and thin layer chromatography.
		Upon completion of the course, students will be able to learn: The Atmosphere: composition and structure of the atmosphere; troposphere, stratosphere, mesosphere and thermosphere; ozone layer and its role; major air pollutants: CO, SO_2, NO_x and particulate matters – their origin and harmful effects; the problem of ozone layer depletion; greenhouse effect; acid rain and photochemical smog; air pollution episodes: air quality standard; air pollution control measures: cyclone collector, electrostatic precipitator, the catalytic converter. The Hydrosphere: environmental role of water, natural water sources, water treatment for industrial, domestic and laboratory uses; water pollutants; the action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution, radioactive pollution and their effects on animal and plant life; water pollution episodes: water pollution control measures: wastewater treatment; chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters; desalination of sea water: reverse osmosis, electrodialysis. The Lithosphere: water and air in soil, waste matters and pollutants in soil, waste classification, treatment and disposal; soil pollution and control measures.
	Analytical Industrial Chemistry	Upon completion of the course, students will be able to learn: Error analysis: accuracy and precision of quantitative analysis, determinate, indeterminate, systematic and random errors; methods of least squares and standard deviations. Computer applications: general introduction to computers, different components of a computer; hardware and software; input and output devices; binary numbers and arithmetic; introduction to computer languages; programming and operating systems.
		Upon completion of the course, students will be able to learn: Fuels: classification of fuel; heating values; origin of coal, carbonization of coal, coal gas, producer gas, water gas, coal-based chemicals; origin and composition of petroleum, petroleum refining, cracking, knocking, octane number, antiknock compounds, kerosene, liquefied petroleum gas (LPG), liquefied natural gas (LNG); petrochemicals (C1 to C3 compounds and their uses). Fertilizers: manufacture of ammonia and ammonium salts, urea, superphosphate, and biofertilizers. Glass and ceramics: definition and manufacture of glasses, optical glass and coloured glass; clay and feldspar, glazing and vitrification, glazed porcelain, enamel. Cement: portland cement: composition and setting of cement, white cement.
CHEMISTRY-UG PAPER-CHEMGPDSE-1 (Practical) Sem-V	Analytical and Environmental Chemistry	Upon completion of the course, students will be able to learn: 1. To find the total hardness of water by EDTA titration. 2. To find the pH of an unknown solution by comparing color of a series of HCl solutions + 1 drop of methyl orange, and a similar series of NaOH solutions + 1 drop of phenolphthalein. 3. To determine the rate constant for the acid-catalysed hydrolysis of an ester. 4. Determination of the strength of the H_2O_2 sample. 5. To determine the solubility of a sparingly soluble salt, e.g. KHTa (one bottle)
	Analytical and	Upon completion of the course, students will be able to learn:

	Industrial Chemistry	Titration of Na_2CO_3 and $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators. Titration of HCl and CH_3COOH mixture vs NaOH using two different indicators to find the concentration. Estimation of available oxygen in pyrolusite
Chemistry UG (CBCS) Semester-VI		
CHEMISTRY-UG PAPER-CHEMGTDSE-2 (Theory) Sem-VI	Advanced Organic Chemistry	Upon completion of the course, students will be able to learn: Carboxylic acids (aliphatic and aromatic): strength of organic acids: a comparative study with emphasis on factors affecting pK values; Preparation: acidic and alkaline hydrolysis of esters ($B_{AC}2$ and $A_{AC}2$ mechanisms only) and from Grignard reagents; Reactions: Hell - Vohlard - Zelinsky reaction and Claisen condensation; Perkin reaction. Carboxylic acid derivatives (aliphatic): (up to 5 carbons). Preparation: acid chlorides, anhydrides, asters and amides from acids; Reactions: Comparative study of the nucleophilicity of acyl derivatives; interconversion among acid derivatives.
		Upon completion of the course, students will be able to learn: Amines (aliphatic and aromatic): strength of organic bases; Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann degradation, by reduction of nitro compounds; Reactions: with HNO_2 (distinction of 1°-, 2°- and 3°- amines), Schotten – Baumann reaction, Diazo coupling reaction (with mechanism). Diazonium salts: Preparation: from aromatic amines; Reactions: conversion to benzene, phenol, benzoic acid and nitrobenzene. Nitro compounds (aromatic): reduction under different conditions (acidic, neutral and alkaline).
		Upon completion of the course, students will be able to learn: a. Amino Acids: Preparations (glycine and alanine only): Strecker synthesis, Gabriel's phthalimide synthesis; general properties; zwitterion, isoelectric point; ninhydrin reaction. Carbohydrates: Classification and general properties; glucose and fructose: constitution; osazone formation; oxidation-reduction reactions; epimers of glucose
	Industrial Chemistry	Upon completion of the course, students will be able to learn: Basic concept, structure and types of plastics, polythene, polystyrene, phenol formaldehyde, and PVC; manufacture, physical properties and uses of natural rubber, synthetic rubber, silicone rubber; synthetic fibres, nylon-66, polyester, terylene, rayon; foaming agents, plasticizers and stabilizers.
		Upon completion of the course, students will be able to learn: Primary constituents; formulation of paints; binders and solvents for paints; oil-based paints, latex paints, alkyd resin paint.
		Upon completion of the course, students will be able to learn: Constituents of varnishes; formulation of varnishes.
		Upon completion of the course, students will be able to learn: Synthesis of methyl orange, congo red, malachite green, crystal violet
		Upon completion of the course, students will be able to learn: Concept and necessity of drugs and pharmaceuticals; preparation and uses: aspirin, paracetamol, sulphadiazine, quinine, chloroquine, phenobarbital, metronidazole.
		Upon completion of the course, students will be able to learn: Production and

		purification of ethyl alcohol, citric acid, lactic acid, vitamin B12, penicillin.
		Upon completion of the course, students will be able to learn: Natural fat, edible and inedible oil of vegetable origin; common fatty acids; glycerides; hydrogenation of unsaturated oil, production of vanaspati and margarine
		Upon completion of the course, students will be able to learn: Production of toilet and washing soaps; enzyme-based detergents, detergent powder; liquid soaps
		Upon completion of the course, students will be able to learn: Common pesticides: production, applications and residual toxicity of gammaxane, aldrin, parathion, malathion, DDT, paraquat, decamethrin.
		Upon completion of the course, students will be able to learn: Food flavour, food colour, food preservatives, artificial sweeteners, acidulants, alkalies, edible emulsifiers and edible foaming agents, sequestrants – uses and abuses of these substances in food beverages.
CHEMISTRY-UG PAPER-CHEMGPDSE-2 (Practical) Sem-VI	Advanced Organic Chemistry	Upon completion of the course, students will be able to learn- 1. The following reactions are to be performed, noting the yield of the crude product: a. Nitration of aromatic compounds b. Condensation reactions c. Hydrolysis of amides/imides d. Acetylation of aromatic amines e. Benzoylation of aromatic amines 2. Purification of the crude product is to be made by crystallisation from water/alcohol.
	Industrial Chemistry	Upon completion of the course, students will be able to learn- 1. Estimation of saponification value of oil / ester / fat. 2. Estimation of available chlorine in bleaching powder. 3. Estimation of acetic acid in commercial vinegar. 4. Estimation of amino acid by formol titration