Bankim Sardar College
A College with Potential for Excellence

Department of Chemistry

Programme Specific Outcome (PSO) - Course Outcome (CO)

Programme Specific Outcome (PSO) :

PSO 01. To understand basic facts and concepts in Chemistry while retaining the exciting aspects of Chemistry so as to develop interest in the study of chemistry as a discipline.
PSO 02. To develop the ability to apply the principles of Chemistry.
PSO 03. To appreciate the achievements in Chemistry and to know the role of Chemistry in nature and in society.
PSO 04. To develop problem solving skills.
PSO 05. To be familiarised with the emerging areas of Chemistry and their applications in various spheres of Chemical sciences and to apprise the students of its relevance in future studies.
PSO 06. To develop skills in the proper handling of apparatus and chemicals.
PSO 07. To be exposed to the different processes used in industries and their applications.

Core Courses	Content of CU Syllabus	Course Outcome
Semester 1		
CCH01A	**INORGANIC CHEMISTRY-1** **Extra nuclear Structure of atom** Quantum numbers and their significance, Schrödinger's wave equation, significance of ψ and ψ^2. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Pauli's Exclusion Principle, Hund's rules and multiplicity, Exchange energy, Aufbau principle and its limitations, Ground state Term symbols of atoms and ions for atomic number upto 30. **Acid-Base reactions** Acid-Base concept: Arrhenius concept, theory of solvent system (in H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling's rules. Lux-Flood concept, Lewis concept, group characteristics of Lewis acids, solvent leveling and differentiating effects.Thermodynamic acidity parameters, Drago-Wayland equation.	Students will be able to *CO 01.* Develop an ability to use conceptual and mathematical tools to express and predict atomic and molecular behavior *CO 02.* Discuss the Quantum mechanical concept of atom in the light of modern chemistry *CO 03.* Interpret and explain the theories associated with various acid –base reactions *CO 04.* Perceive the electronic interpretations of Reduction and Oxidation reactions *CO 05.* Make use of an analytical balance

	Superacids, Gas phase acidity and proton affinity; HSAB principle. Acid-baseequilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer.Acid-base neutralisation curves; indicator, choice of indicators. **Redox Reactions** Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples). 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. Solubility and solubility effect – common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides **Practical:** **Acid and Base Titrations: (DEMO ONLY)** 1. Estimation of carbonate and hydroxide present together in mixture 2. Estimation of carbonate and bicarbonate present together in a mixture. 3. Estimation of free alkali present in different soaps/detergents. **Oxidation-Reduction Titrations:** 1. Estimation of Fe(II) using standardized $KMnO_4$ solution 2. Estimation of oxalic acid OR sodium oxalate in a given mixture 3. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution. 4. Estimation of Fe(III) and Mn(II) in a mixture using standardized $KMnO_4$ solution 5. Estimation of Fe(III) and Cu(II) in a mixture using $K_2Cr_2O_7$. 6. Estimation of Fe(III) and Cr(III) in a mixture using $K_2Cr_2O_7$.	for mass measurement *CO 06.* Make use of graduated cylinders, graduated pipettes, and volumetric pipettes for volumetric measurement *CO 07.* Have hands on experience of different common laboratory techniques like acid/base titrations and redox titrations *CO 08.* Undertake experiments in laboratory condition for the estimation of metals in different mixtures
CCH01B	**Basics of Organic Chemistry** **1.Bonding and Physical Properties** *(i) 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). *(ii) 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	The students will develop a clear concept of *CO 09.* The Valence bond *CO 10.* Various Electronic displacements effects *CO 11.* Molecular Orbital Theory for Highest Occupied Molecular Orbital (HOMO), Lowest Unoccupied Molecular orbital (LUM and Single occupied Molecular Orbital (SOMO) *CO 12.* Aromaticity, Antiaromaticity, Homoaromaticity and Non

	antibonding interactions, idea about σ, σ^*, π, π^*, n – MOs; concept of HOMO, LUMO and SOMO; 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 [8] annulene (including mononuclear heterocyclic compounds up to 6- membered ring); concept of antiaromaticity and homoaromaticity; non-aromatic molecules; Frost diagram (qualitative drawing). *Physical properties:* influence of hybridization on bond properties: bond dissociation energy (BDE) and bond energy; bond distances, bond angles; concept of bond angle strain; melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments; relative stabilities of isomeric hydrocarbons in terms of heat of hydrogenation and heat of combustion data. **2. General Treatment of Reaction Mechanism** *Mechanistic classification:* ionic, radical and pericyclic (definition and example); reaction type: addition, elimination and substitution reactions (definition and example); nature of bond cleavage and bond formation: homolytic and heterolytic bond fission, homogenic and heterogenic bond formation; curly arrow rules in representation of mechanistic steps; reagent type: electrophiles and nucleophiles (elementary idea). **Practical** Separation based upon solubility, by using common laboratory reagents like water (cold,hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, *etc*., of components of a binary solid mixture; purification of **any one** of the separated components by crystallization and determination of its melting point. The composition of the mixture should be of the following types :*p*-Nitrobenzoic acid/*p*-Aminobenzoic acid; *p*-Nitrotolune/*p*-Anisidine; benzoic acid/naphthalene; urea/phenyl benzoate; *p*-toluidine/benzophenone; *p*-chlorobenzoic acid/ benzophenone, Benzoic acid/Anthracene; Glucose/Biphenyl; Benzoic acid/Benzophenone; Urea/Benzophenone. Use of pH paper is recommended.	aromaticity *CO 13.* Several Physical properties such as bond dissociation energy and bond energy; bond distances, bond angles, bond angle strain, polarity, Heat of Hydrogenation and heat of combustion etc. The students will be able to develop an understanding of *CO 14.* Definition of Reaction mechanism and Mechanistic classification e.g, ionic, radical and pericyclic mechanism *CO 15.* Explanation of ionic mechanism with examples *CO 16.* Explanation of pericyclic mechanism with examples *CO 17.* Examples and reason of homolytic and heterolytic bond cleavage *CO 18.* Examples and reason of homogenic and heterogenic bond formation *CO 19.* Representation of mechanistic steps using arrow formalism *CO 20.* Basic idea of electrophilesand nucleophiles The students will be able to distinguish different organic compounds from the given mixture by *CO 21.* Separation based upon solubility *CO 22.* Purification based on crystallization using proper solvents *CO 23.* Determination of its melting point by using Conc. H_2SO_4 Bath, Metal bath

CCH02A	**PHYSICAL CHEMISTRY-1** **Kinetic Theory and Gaseous state** Kinetic Theory of gases: Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion 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≥ε, Principle of equipartitionof 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 behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour, other equations of state (Berthelot, Dietrici); Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; virial equation of state; van der Waals equation expressed in virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea) **Transport processes** **Diffusion :** Fick's law, Flux, force, phenomenological coefficients & their interrelationship (general form), different examples of transport properties **Viscosity:** General features of fluid flow (streamline flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation (with derivation); principle of determination of viscosity coefficient of liquids by falling sphere method and using Ostwald's viscometer. Temperature variation of viscosity of liquids and comparison with that of gases. Relation between viscosity coefficient of a gas and mean free path. **Chemical kinetics** 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; Rate determining step and steady-state approximation – explanation with suitable examples;) Opposing reactions, consecutive reactions and parallel reactions (with explanation of kinetic and thermodynamic control of products; all steps first order). Role of Temperature : Temperature dependence of rate constant; Arrhenius equation, energy of activation; Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Enzyme catalysis; Michaelis-Menten equation,	Students will be able *CO 01.* To understand kinetic theory of gases *CO 02.* To get an introduction to the basic concepts of pressure, temperature and velocity of ideal gases. *CO 03.* To get a picture about the probability of finding a molecule with a speed falling in a particular range *CO 04.* To explain the key concepts of degree of freedom, equipartition of energy and specific heat *CO 05.* To get a concept of collision among molecules and with the wall *CO 06.* To understand deviation of real gas from ideal behavior. *CO 07.* To understand critical constant and vanderwall's constant. *CO 08.* To learn about the different intermolecular forces *CO 09.* To be able to derive rate equations from mechanistic data *CO 10.* To make use of simple models for predictive understanding of physical phenomena associated to kinetics *CO 11.* To study the dependence of the rate of chemical reactions on properties like pressure, temperature, presence of catalyst *CO 12.* To understand transport properties

	Lineweaver-Burk plot, turn-over number. **Practical:** **Experiment 1**: Study of kinetics of decomposition of H2O2 **Experiment 2**: Study of kinetics of acid-catalyzed hydrolysis of methyl acetate **Experiment 3**: Study of viscosity of unknown liquid (glycerol, sugar) with respect to water. **Experiment 4**: Study of the variation of viscosity with the concentration of the solution **Experiment 5**: Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator)	*CO 13.* To have a hands on experience about the different concepts of kinetics theory, flow properties and solubility
CCH02B	**Organic Chemistry** **Stereochemistry I** Bonding geometries of carbon compounds and representation of molecules:tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying wedge and Newman projection formulae and their inter translations. Concept of chirality and symmetry:symmetry elements, molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of stereogenicity, chirotopicity and pseudoasymmetry; chiral centres and number of stereoisomerism: systems involving 1/2/3-chiral centre(s) (AA, AB, ABA and ABC types). Relative and absolute configuration:D/L and *R/S* descriptors; *erythro/threo*and *meso*nomenclature of compounds; *syn/anti* nomenclatures for aldols; *E*/*Z* descriptors for C=C, conjugated diene, triene, C=N and N=N systems; combination of *R/S*- and *E/ Z*-isomerisms. Optical activity of chiral compounds:optical rotation, specific rotation and molar rotation; racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates); resolution of acids, bases and alcohols *via* diastereomeric salt formation; optical purity and enantiomeric excess; invertomerism of chiral trialkylamines. **General Treatment of Reaction Mechanism II** **Reactive intermediates:**carbocations (carbenium and carbonium ions), non-classical cabocations, carbanions, carbon radicals, carbenes: generation and stability, structure using orbital picture and electrophilic/nucleophilic behavior of reactive intermediates (elementary idea).	Students will gather knowledge about *CO 14.* the three dimensional structure of any Sp3hybridised chiral organic compound by understanding *CO 15.* Bonding geometries of carbon compounds and representation of molecules by Projection Formulae,Interconversion of a three dimensional structure, Chirality and asymmetry, Dextrorotatory and laevorotatory isomers *CO 16.* Concept of chirality and symmetry by Definition with examples of Symmetry elements and its classification, optical isomers , Concept of Stereogenicity and Chirotopicity , Difference between them *CO 17.* Definition and rules of writing Relative (D-L)and absolute (R-S)Configuration and also their Assignments, Examples of threo/erythro nomenclatures for aldols with definition, syn/anti, cis/trans , E/Z *CO 18.* Optical activity of chiral compounds by optical rotation, specific rotation, optical purity or enantiomeric excess, Definition classification of racemic modification, racemisation and

		resolution. invertomerism of trialkylamines *CO 19.* Students will have a clear concept of Structures, Types and Applications of Reactive intermediates and their stabilities. *CO 20.* Electrophilic behavior of Carbocations&Nucleophilic behavior of Carbanions *CO 21.* Electrophilic / Nucleophilic behavior of Carbon Radicals *CO 22.* Elementary idea of generation and fate of the all intermediates
	ORGANIC CHEMISTRY: O(1B)LAB **Determination of boiling point** of common organic liquid compounds :*n*- butyl alcohol, cyclohexanol, ethyl methyl ketone, cyclohexanone, acetylacetone,isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde and acetophenone. [Boiling points of the chosen organic compounds should preferably be within180^{0}C].	ORGANIC CHEMISTRY: O (1B) LAB *CO 23.* The students will be able to determine the boiling points of common organic liquid compounds by using boiling point bath.

Core Courses	Content of CU Syllabus	Course Outcome
Semester 2		
CCH 03	**Stereochemistry II** Chirality arising out of stereoaxis: stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, spiro compounds, alkylidenecycloalkanes and biphenyls;relatedconfigurational descriptors (R_a/S_a);atropisomerism; racemisation of chiral biphenyls. Concept of prostereoisomerism: prostereogeniccentre; concept of (*pro*)^n-*chirality*: topicity of ligands and faces (elementary idea); *pro-R/pro-S*, *pro-E/pro-Z* and *Re/Si* descriptors;*pro*-rand *pro-s*	The 2nd part of Stereochemistry will give the students a clear picture of *CO 01.* Chirality arising out of stereoaxis in allens and biphenyls Atropisomerism, Assignment of R/S descriptor in allenes and biphenyls *CO 02.* Concept of prostereoisomerism,

	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*). ***General Treatment of Reaction Mechanism III*** **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; comparison between nucleophilicity and basicity; 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-enoltautomerism; application of thermodynamic principles in tautomeric equilibria. **Reaction kinetics*:*** rate constant and free energy of activation; free energy profiles for one-step, two-step and three-step reactions; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and β-secondary kinetic isotopic effect (k_H /k_D); principle of microscopic reversibility; Hammond's postulate. ***Substitution and Elimination Reactions*** **Free-radical substitution reaction***:* halogentaion of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate. **Nucleophilic substitution reactions***:* substitution at sp^3 centre[systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, α-halocarbonyls]:mechanisms (with evidence),relative rates& stereochemical features: S_N1, S_N2, S_N2', S_N1' (allylic rearrangement) and S_Ni; effectsof solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP (with hetero atoms and aryl groups); role of crown ethers and phase transfer catalysts. **Elimination reactions*:*** E1, E2, E1cB and Ei (pyrolytic *syn*	prochirality, prostereogenicity, Topicity of ligands and faces, Pseudoasymmetry, Pro-R and Pro-S designation of enantiotopic groups, Re /Si designation designation of enantiotopicnddiastereotopic faces *CO 03.* Conformational nomenclature, Determination of conformational analysis and Potential Energy diagram of various hydrocarbons, halohydrocarbons glycols *CO 04.* Reaction thermodynamics i.e., basic idea about free energy, Equilibrium, enthalpy, entropy, by Explaining intermolecular &intramolecular reactions with examples *CO 05.* Concept of organic acids and bases,their structure, effect of substituent, solvent on acidity and basicity *CO 06.* Definition and types of tautomerism with examples *CO 07.* Concept of Reaction kinetics with Free energy profiles for one and multi step reactions with rate constant and free energy of activation , Free energy profiles for catalysed reactions (electrophilic and nucleophiliccatalysed reactions), Kinetic control and thermodynamic control of reactions, Primary kinetic isotopic effect (kH/kD), *CO 08.* Hammond postulate After studying this topic students will gain the knowledge of the followings *CO 09.* Concept, Types& Role of leaving group (SN1, SN2, SNi) and Mechanisms of Sustitution Reaction at sp3 centre *CO 10.* Concept, Types and Mechanisms of elimination reactions.(E1, E2 and E1cB), Reactivity of different substrates on elimination reactions, Orientation (Saytzeff/ Hofmann rules) *CO 11.* Substitution vs elimination

	eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination. **Practical** **Organic Preparations** A. The following reactions are to be performed, noting the yield of the crude product: 1. Nitration of aromaticcompounds,2.Condensationreactions, 3.Hydrolysis of amides/imides/esters, 4. Acetylation of phenols/aromaticamines, 5. Brine mediated benzoylation of amines/aminoacids, 6. Side chain oxidation of aromaticcompounds, 7. Diazo coupling reactions of aromaticamines, 8. Bromination of anilides using green approach (Bromate-Bromidemethod),9. Redox reaction including solid-phasemethod, 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. Melting point of the purified product is to be noted.	The students will develop the skill of *CO 12.* Synthesis of some organic compounds given in the syllabus by several methods *CO 13.* Purification of the crude product based on crystallization *CO 14.* Determination of melting point of the Crystals by using Conc. H2SO4 Bath, Metal bath *CO 15.* Calculation of % of Yield.
CCH04	**Chemical Bonding-I** (i) **Ionic bond:** General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals.Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.Defects in solids (elementary idea). Solubility energetics of dissolution process (ii) **Covalent bond:** Polarizing power and polarizability, ionic potential,Fazan's rules. Lewis structures, formal charge. Valence Bond Theory. The hydrogen molecule (Heitler-London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, Dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding (σ and π bondapproach). **Chemical Bonding-II** (i) Molecular orbital concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO))	Students will be able to *CO 01.* Discuss various aspects of chemical bonding in ionic compounds and associated theories. *CO 02.* Explain the reasons of structural defects of various ionic compounds. *CO 03.* Appreciate and explain the concept of chemical bonding in covalent compounds and discuss associated theories thereof. *CO 04.* Explain shape of molecule in the light of VSEPR theory. *CO 05.* Appreciate and explain the theory of LCAO method for molecular orbital designing *CO 06.* Discuss the concept of HOMO, LUMO and Orbital mixing *CO 07.* Draw MO Diagram of Homo nuclear and Hetero nuclear molecules.

	(elementary pictorial approach): sigma and pi- bonds and delta interaction, multiple bonding. Orbital designations: *gerade*, *ungerade*, HOMO, LUMO. Orbital mixing,. MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO^+, CN^-, HF, BeH_2, $CO_2$and H_2O. Bond properties: bond orders, bondlengths. (ii) **Metallic Bond:**Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects insolids. (iii) **Weak Chemical Forces:**Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points. **Radioactivity** Nuclear stability and nuclear binding energy. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation.Separation and uses of isotopes. Radio chemical methods: principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures. **Practical:** Iodo-/ Iodimetric Titrations 1. Estimation of VitaminC 2. Estimation of (i) arsenite and (ii) antimony iodimetrically 3. Estimation of available chlorine in bleachingpowder. *Estimation of metal content in some selective samples* 1. Estimation of Cu in brass. 2. Estimation of Cr and Mn inSteel. 3. Estimation of Fe incement.	*CO 08.* Discuss the various aspects of radioactivity, including nuclear stability, artificial radioactivity, power generation, determination of age of rocks and minerals, safety measures for handling and storage of radioactive compounds. *CO 09.* Undertake iodometric /iodimetricestmation of different important compounds in laboratory condition. *CO 10.* Estimate different constituents of various alloys in laboratory conditions

Core Courses	Content of CU Syllabus	Course Outcome
Semester 3		
CCH05	**Chemical Thermodynamics I** 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*, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence	Students will be able *CO 01.* To provide an insight into some of the fundamental concepts and principles that are very essential in the study of chemistry. *CO 02.* To understand the principle of conservation of energy and how this principle can be used to assess the

	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 ; Adiabatic flametemperature. **ChemicalThermodynamicsII** Second Law:Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of §dQ/T and Clausiusinequality;Physical concept of Entropy; Entropy is a measure of the microscopic disorder of the system. 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 **Systems of Variable Composition:** Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. Activities and activity coefficients. Fugacity and fugacity coefficient. **Applications of Thermodynamics–I** **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; Van't Hoff's reaction isobar and isochore from different standard states; Le Chatelier's principle and its derivation, variation of equilibrium constant under different conditions Nernst's distribution law; Application- (eg. dimerization of benzene in benzoic acid). Solvent Extraction. **ELECTROCHEMISTRY:** **(i) 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; Debye-Huckel	energy changes that accompany physical and chemical processes. CO 03. To examine the means by which a system can exchange energy with its surroundings in terms of the work it may do or the heat it may produce. CO 04. To understand the thermodynamic description of mixtures state function, exact, inexact differential CO 05. To understand the statements of 1st and 2nd laws of thermodynamics. CO 06. To learn the thermodynamic aspects of various processes and reactions. CO 07. To understand the concept of thermochemistry enthalpy change of different processes CO 08. To get the concept of Entropy (S) from Carnot cycle and the significance of Helmholtz free energy(A) & Gibb's free energy (G). CO 09. To explain the criteria of spontaneity in terms of S, A and G. CO 10. To be able to derive important thermodynamic relations CO 11. To learn the basic concept of equilibrium CO 12. To develop an understanding of electrochemistry and the methods used to study the response of an electrolyte through current of potential CO 13. To understand the difference between voltaic/galvanic and electrolytic electrochemical cells. CO 14. To understand why standard reduction potentials are used and how they are determined. CO 15. To know how the standard states used for E° and ΔG° are defined for gases solids liquids and solutes. CO 16. To be able to write balanced half reactions determine overall cell reactions, calculate the standard reduction potential and predict the direction of electron anion and cation flow based on a sketch of an electrochemical cell or the description of an electrochemical cell given in

	limiting law-brief qualitative description. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law. Ostwald's dilution law; Ionic mobility; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometrictitrations.Transport number, Principles of Hittorf's and Moving-boundary method; Wien effect, Debye-Falkenhagen effect, Walden's rule **(ii) Ionic equilibrium:** 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; dissociation constants of mono-, di-and triprotic acids (exacttreatment). Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts (exact Treatment).Determination of hydrolysis constant conductometrically. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action . Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibrium in polyelectrolyte systems; hydrolysis and hydrolysis constants **Electromotive Force**: Rules of oxidation/reduction of ions based on half-cell potentials,; Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Thermodynamic derivation of Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. 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 and glasselectrodes Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers; Potentiometric titrations (acid-base, redox,precipitation)	shorthand notation. *CO 17.* To understand the relationship between chemical energy (Gibbs free energy change for a redox reaction) and electrical energy (electromotive force or cell potential) in an electrochemical cell. *CO 18.* To be prepared to use standard reduction potentials to calculate the standard cell potential E° for an electrochemical cell. *CO 19.* To explain the various terms such as specific conductance, equivalent conductance and molar conductance. *CO 20.* To Explain the method of determination of equivalent conductance understand the factors affecting the conductance of electrolytic solution *CO 21.* To Explain the effect of dilution on specific conductance, equivalent conductance and molar conductance *CO 22.* To understand the ionic mobility of different ions, methods of determination of ionic mobility of ions *CO 23.* To understand Kohlrausch's law and its applications *CO 24.* To understand the basic concepts of Arrhenius theory of electrolytic dissociation, evidences in support of Arrhenius theory of electrolytic dissociation and its limitation, *CO 25.* To understand Ostwald's dilution law and its application in determination of Dissociation constant of weak electrolyte *CO 26.* To understand the need of another theory for strong electrolyte *CO 27.* To understand the term- Electrophoretic and Asymmetric effect *CO 28.* To understand Debye-Huckel theory of strong electrolyte and its mathematical equation *CO 29.* To define -Transport number or transference number of ions *CO 30.* To understand the various methods

	Practical : **Experiment 1**: Conductometric titration of an acid (strong, weak/ monobasic, dibasic, and acid mixture) against strong base. **Experiment 2**: Study of saponification reaction conductometrically **Experiment 3**: Verification of Ostwald's dilution law and determination of K_a of weak acid **Experiment 4:**Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$and$KMnO_4$solution **Experiment 5**: Determination of K_{sp} for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution **Experiment 6**: Determination of heat of neutralization of a strong acid by a strong base	of determination of transport number of ions *CO 31.* To appreciate the importance of conductometric measurement, *CO 32.* To differentiate between various types of conductometric titrations, *CO 33.* To explain the nature of various acid-base titration curves as well as acid mixture versus base graph, *CO 34.* To explain the precipitation titrations and displacement titrations, *CO 35.* To explain and determine the solubility product of any sparingly soluble using conductivity method *CO 36.* To describe the method of determination of ionic product of water using conductometric measurement
CCH06	**Chemical periodicity** Modern IUPAC Periodic table, Effective nuclear charge, screening effects and penetration, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, lanthanide contraction. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) and factors influencing these properties, group electronegativities.Group trends and periodic trends in these properties in respect of s-, p- and d-block elements.Secondary periodicity, Relativistic Effect, Inert paireffect. *Chemistry of* s *and* p *BlockElements* Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation.Hydrides and their classification ionic, covalent and interstitial.Basic beryllium acetate and nitrate.Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.Beryllium hydrides and halides.Boric acid and borates, boron nitrides, borohydrides (diborane) and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, phosphorus, sulphur and chlorine.Peroxo acids of sulphur, sulphur-nitrogen compounds, interhalogen compounds, polyhalide ions, pseudohalogens, fluorocarbons and basic properties of halogens. *Noble Gases:* Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2 and XeF_4). Xenon-oxygen	**Students will be able to** *CO 01.* Discuss the properties of different elements in the periodic table . *CO 02.* Discuss the methods of preparation,-properties and structure of different useful chemical compounds . *CO 03.* Effectively articulate various aspects of the noble gases' chemistry. *CO 04.* Explain the chemistry of Inorganic Polymers *CO 05.* Discuss about the Co ordination Compounds with respect to their nomenclature, classification and geometries

	compounds. Molecular shapes of noble gas compounds (VSEPR theory). *Inorganic Polymers:* Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes.Borazines, silicates and phosphazenes. *CoordinationChemistry-I* Coordinate bonding: double and complex salts. Werner's theory of coordination complexes, Classification of ligands, Ambidentate ligands, chelates, Coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedralcomplexes. **Practical:** *Complexometric titration* 1. Zn(II) 2. Zn(II) in a Zn(II) and Cu(II)mixture. 3. Ca(II) and Mg(II) in amixture. 4. Hardness ofwater. 5. Al(III) in Fe(III) and Al(III) in amixture *Chromatography of metal ions* Principles involvedin chromatographicseparations. Paper chromatographic separation of following metalions: 1. Ni (II) and Co(II) 2. Fe (III) and Al(III) *Gravimetry* 1. Estimation of Ni(II) using Dimethylglyoxime(DMG). 2. Estimation of copper asCuSCN. 3. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$(aluminiumoxinate). 4. Estimation ofchloride	*CO 06.* Estimate quantitatively metals present in different mixtures complexometrically in laboratory condition *CO 07.* Estimate quantitatively particular metal ions from a mixture following paper chromatography technique *CO 08.* Estimate quantitatively different metals following Gravimetric Method
CCH07	**Chemistry of alkenes and alkynes** **Addition to C=C:**mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenation, hydrohalogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation, epoxidation, *syn* and *anti*-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; Simmons-Smith cyclopropanation reaction; electrophilic addition to diene (conjugated dienes and allene); radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; Birch reduction of benzenoid aromatics; interconversion of *E*- and *Z*- alkenes; contra-thermodynamic isomerization of internal alkenes. **Addition to C≡C (in comparison to C=C***):*mechanism, reactivity,	The students will develop the knowledge of Addition reaction by learning *CO 01.* The Mechanism, Reactivity of Electrophilic Addition to C=C bond with different electrophiles, Difference between regioselectivity, stereoselectivity, Ozonolysis reactions with mechanism, allylic and benzylicbromination, use of NBS, Birch reduction of benzenoid aromatics, interconversion of E- and Z- alkenes, electrophiilic addition to conjugated diene, allenes *CO 02.* Mechanism and Reactivity of Electrophilic Addition to C≡C *CO 03.* The acidities of the terminal alkynes

	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. **Aromatic Substitution** **Electrophilic aromatic substitution***:*mechanisms and evidences in favour of it; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbonelectrophiles (reactions:chloromethylation, Gatterman-Koch, Gatterman, Houben-Hoesch,Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmitt); *Ipso* substitituion. **Nucleophilic aromatic substitution***:*addition-elimination mechanism and evidences in favour of it; S_N1 mechanism; cine substitution (benzyne mechanism), structure of benzyne. **Carbonyl and Related Compounds** *Addition to C=O:* structure, reactivity and preparation of carbonyl compounds; mechanism (with evidence), reactivity, equilibrium and kinetic control; formation of hydrates, cyanohydrins and bisulphite adduct; nucleophilic addition-elimination reactions with alcohols, thiolsand nitrogen- based nucleophiles;reactions: benzoin condensation, Cannizzaro and Tischenko reactions, reactions with ylides: Wittig and Corey-Chaykovsky reaction; Rupe rearrangement, oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, 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,Tollens', Knoevenagel, Claisen-Schmidt, Claisen ester including Dieckmann, Stobbe; Mannich reaction,Perkin reaction, Favorskii rearrangement; alkylation of active methylene compounds; preparation and synthetic applications of diethyl malonate and ethyl acetoacetate; specific enol equivalents (lithium enolates, enamines and silyl enol ethers) in connection with alkylation, acylation and aldol type reaction. .**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 annulation. *Substitution at* sp^2 *carbon (C=O system):* mechanism (with evidence): $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (inconnection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).	*CO 04.* Interconversion of terminal and non-terminal alkynes The students will understand the *CO 05.* General Mechanism, Orientation, Reactivity of different Electrophilic aromatic substitution *CO 06.* Mechanism of Nucleophilic aromatic substitution Students will achieve the knowledge on *CO 07.* Mechanism and Reactivity of Nucleophilic addition to Carbonyl and Related Compounds with different nucleophiles *CO 08.* Mechanism of some condensation, reduction and oxidation reaction of carbonyls *CO 09.* Exploitation of acidity of α-H of C=O by alkylation, halogenations, aldolcondensationetcrection *CO 10.* Some named rearrangements with mechamism *CO 11.* Alkylation of active methylene compounds (diethyl malonate and ethyl acetoacetate)with mechamism *CO 12.* Mechanism of Nucleophilic addition to α,β-unsaturated carbonyl system *CO 13.* Substitution at sp2 carbon (C=O system) by esterification and Hydrolysis (BAC2, AAC2, AAC1, AAL1), amide, Anhydrides, Acyl halides formation and their corresponding hydrolysed products. Students be knowledgable about *CO 14.* The General Idea, Structure and Types of Organometallic compounds. Few examples. *CO 15.* Preparation of Grignard reagent and organo lithium with mechanism *CO 16.* Mechanism of the addition reactions of Grignard reagents, organo lithium and Gilman cuprates to different electrophilic sites *CO 17.* Mechanism of Reformatsky reaction, Blaise reaction by using organozinc compound *CO 18.* Some abnormal behaviours of Grignard reagents

	Organometallics **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 behaviour of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; Blaise reaction; concept of *umpolung* **Practical:** **Identification of a Pure OrganicCompound** **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 **Quantitative Estimations:** Each student is required to perform all the experiments . Estimation of glycine by Sörensen'sformolmethod . Estimation of glucose by titration using Fehling'ssolution . Estimation of sucrose by titration using Fehling'ssolution . Estimation of aromatic amine (aniline) by bromination (Bromate-Bromide)method . Estimation of acetic acid in commercialvinegar . Estimation of urea (hypobromitemethod) . Estimation of saponification value ofoil/fat/ester	*CO 19.* comparison of reactivity among Grignard, organolithiums and organocopper reagents *CO 20.* Reversal of polarity. i.e., Umpolung The students will be able to identify a single compound *CO 21.* Single organic compounds can be identified by checking its Physical state (Solid and Liquid) *CO 22.* Then Identification of some solid and liquid compounds are done primarily by using *CO 23.* litmus paper, Solubility test, Action of heat,FeCl3 test, Silver mirror test, Fluorescence test, Fehling's test etc. *CO 24.* After having the idea about the probable name and nature of the compound it is identified correctly by doing a single test for each solid and liquid compounds. *CO 25.* Developing the skill for estimating different organic compound solutions quantitatively
SECA	**Analytical Clinical Biochemistry** **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 ChemicalIndustry. **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.	Students will be able to *CO 01.* Explain the structure carbohydrates and amino acids, their physical and chemical properties and their function in living organisms. *CO 02.* Describe the function of enzyme as a catalyst in maximum biological reaction and learn about the function of enzyme, and also see how they are related to things they come across in daily life. *CO 03.* Understand the effect of cholesterol and triglycerides in human body *CO 04.* Knowabout steroid hormone which regulates carbohydrate metabolism and has an anti-inflammatory effect on the body. It helps maintain blood pressure and regulate the salt and water balance in our body. *CO 05.* understand some of the types of disease that might be treatable by

	Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of **DNA and RNA:** Replication, Transcription and Translation, Introduction to Gene therapy. **Biochemistry of disease: A diagnostic approach by blood/ urine analysis.** **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***:* Collection and preservation of samples. Formation of urine.Composition and estimation of constituents of normal and pathological urine. **Hands On Practical** Identification and estimation of the following: 1. Carbohydrates – qualitative andquantitative. 2. Lipids –qualitative. 3. Determination of the iodine number ofoil. 4. Determination of the saponification number ofoil. 5. Determination of cholesterol using Liebermann-Burchardreaction. 6. Proteins –qualitative. 7. Isolation ofprotein. 8. Determination of protein by the Biuretreaction. 9. Determination of nucleicacids	gene therapy *CO 06.* understand how genetics may be used in the design of drugs. *CO 07.* know various biochemical tests to determine glucose, lipids, creatinine and albumin in blood. Correlate laboratory test results with common diseases or conditions *CO 08.* know the pathophysiological bases of the most relevant and prevalent diseases in our population; the main biological properties that are altered in these diseases and are examined in a clinical biochemistry laboratory;

Core Courses	**Content of CU Syllabus**	**Course Outcome**
Semester 4		
CCH08	**Nitrogen compounds** **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, formation and reactions of phenylenediamines, diazomethane and diazoacetic ester. **Nitro compounds (aliphatic and aromatic):** preparation and reaction (with mechanism): reduction under different conditions; Nef	The students will have a preliminary idea about *CO 01.* The structural differences of Amines: Aliphatic & Aromatic, Preparation, Separation and Basicity of aliphatic and aromatic amines, Identification of primary, secondary and tertiary amines several reactions of amines

	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. **Rearrangements(1)** Mechanism with evidence and stereochemical features for the following: Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, benzil- benzilicacid rearrangement, Demjanovrearrangement,Tiffeneau–Demjanov rearrangement **Rearrangements(2)** Mechanism with evidence and stereochemical features for the following: Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, cumene hydroperoxide-phenol rearrangement and Dakin reaction. **Rearrangements(3)** Mechanism with evidence and stereochemical features for the following: Aromatic Rearrangement to electron-deficient nitrogen: rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann **Rearrangements(4)** Mechanism with evidence and stereochemical features for the following: rearrangements: Migration from oxygen to ring carbon: Fries rearrangement and Claisen rearrangement **Rearrangements(5)** Mechanism with evidence and stereochemical features for the following: Migration from nitrogen to ring carbon: Hofmann-Martius rearrangement**,** Sommelet Hauser rearrangement, Fischer-Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement, Orton rearrangement and benzidine rearrangement. **The Logic of Organic Synthesis *(1) Retrosynthetic analysis***: Disconnections; synthons, donor and acceptor synthons; natural reactivity and *umpolung*; latent polarity in bifunctional compounds: illogical electrophiles and nucleophiles; synthetic equivalents; functional group interconversion and addition (FGI and FGA) **The Logic of Organic Synthesis *(2) Retrosynthetic analysis***: C-C disconnections and synthesis: one-group and two- group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl); 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); diastereoselectivity: addition of nucleophiles to C=O adjacent to a stereogenic centre: Felkin-Anh model.	with mechanism *CO 02.* The preparation of Nitro compounds (aliphatic and aromatic), reduced products of nitro compounds on acidic, neutral and alkaline condition *CO 03.* The various methods for preparing Alkylnitrile and isonitrile *CO 04.* Preparation of aromatic Diazonium salts and their related compounds, to replace the N≡N group by different groups, couplingproducts The students will learn different types of rearrangements including *CO 05.* Rearrangement to electron deficient carbon, *CO 06.* Rearrangement to electron deficient oxygen, *CO 07.* Rearrangement to electron deficient nitrogen *CO 08.* Migrating the group from oxygen to ring carbon *CO 09.* Migrating the group from nitrogen to ring carbon Students will have a clear idea about the logic of organic synthesis by retrosynthetic approach after studying the following *CO 10.* Some Definitions related to retro synthesis *CO 11.* How to do One-Group, Two-Group C-C disconnections and then synthesize, Concept of Reconnection and Protection-deprotection strategy *CO 12.* Strategy of ring synthesis:Medium and large rings may be synthesized by high dilution principle.

	Organic Spectroscopy(1) *UV Spectroscopy* *:* introduction; types of electronic transitions, end absorption; transition dipole moment and allowed/forbidden transitions; chromophores and auxochromes; Bathochromic andHypsochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); application of Woodward's Rules for calculation of λ_{max} 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 λ_{max} considering conjugative effect, steric effect, solvent effect, effect of pH; effective chromophore concentration: keto-enol systems; benzenoid transitions. ***Organic Spectroscopy(2)*** *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. ***Organic Spectroscopy(3)*** *NMR Spectroscopy* introduction;nuclear spin; NMR active molecules;basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect;significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of *first-order* multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR ; 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. **Organic Spectroscopy(4)** Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules ***Experiment: Qualitative Analysis of Single Solid Organic***	*CO 13.* Asymmetric synthesis: Streoselective Reactions, Stereospecific Reactions, Diastereoselectivity, Enantiosectivity, *CO 14.* Diastereoselective synthesis may be carried out by applying Cram's rule using Felkin-Anh model for addition of nucleophiles to C=O adjacent to a stereogeniccentre. The student will have a clear concept of *CO 15.* Emission Spectroscopy *CO 16.* Absorption Spectroscopy. *CO 17.* It is again divided into the following heads *CO 18.* UV Spectroscopy : *CO 19.* IR Spectroscopy *CO 20.* NMR Spectroscopy Students will know about the *CO 21.* The basic fundamental knowledge which are acquired in the previous modules (MXIII, MXIV and MXV) for identification of simple organic

	Compounds 1. Detection of special elements (N, S, Cl, Br) by Lassaigne's test 2. Solubility and classification (solvents: H2O, 5% HCl, 5% NaOH and 5% NaHCO3) 3. Detection of the following functional groups by systematic chemical tests: aromatic amino (-NH2), aromatic nitro (-NO2), amido (-CONH2, including imide), phenolic –OH, carboxylic acid (-COOH), carbonyl (distinguish between -CHO and >C=O); only one test for each functional group is to be reported. 4. Melting point of the given compound 5. Preparation, purification and melting point determination of a crystalline derivative of the given compound. 6. Identification of the compound through literature survey. Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups with relevant derivatisation in known and unknown (**at least six)** organic compounds.	molecules After completing this module students will be able to analyse the given single solid organic compound by *CO 22.* Detection of special element by Lassaigne's test *CO 23.* Solubility and classification *CO 24.* Identification of nitrogeneous and non-nitrogeneous functional groups. *CO 25.* The structure of the given compound may be achieved by corresponding suitable derivative preparation and *CO 26.* Melting point determination of both the given sample and the derivative prepared.
CCH09	**Application of Thermodynamics–II** **Colligative properties**: Vapour pressure of solution; Ideal solutions, ideally diluted solutions and colligative properties; Raoult's law; Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) 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 Equilibrium**: 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; Ehrenfest Classification of phase transition. Binary solutions: Liquid vapour equilibrium for two component systems 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 Three component systems, water-chloroform-acetic acid system, triangular plots	Students will be able *CO 01.* To understand Raoult's law *CO 02.* To compare Henry's law and Raoult's law to explain ideal solutions *CO 03.* To describe ideal liquid mixtures. *CO 04.* To discuss P-C and T-C diagrams and the usefulness *CO 05.* To explain non-ideal liquid-vapour systems. *CO 06.* To state and explain azeotropic mixtures. *CO 07.* To explain partially miscible and immiscible liquid systems by taking appropriate examples. *CO 08.* To describe how a solute distribute itself in two immiscible liquids, *CO 09.* To state and explain Nernst's distribution law, *CO 10.* To apply and derive an expression for modified Nernst distribution law for a special case in which solute associate or dissociate in one of the solvent , *CO 11.* To classify systems as heterogeneous and homogeneous systems

	Foundation of QuantumMechanics Beginning of Quantum Mechanics: Black body radiation (Concept only) Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (without proof) Wave function: Postulates of Quantum Mechanics, Schrodinger time-independent equation; nature of the equation, acceptability conditions for the wave functions and probability interpretations of wave function Vector representation of wave function. Orthonormality of wave function. Concept of Operators: Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators; Commutation of operators, commutator and uncertainty relation; Expectation value; Properties of Hermitian operator; Complete set of Eigenfunctions.Expansion of Eigenfunctions. Particle in a box: Setting up of Schrodinger equation for one-dimensional box and its solution; Comparison with free particle eigenfunctions and eigenvalues. Properties of PB 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. ***Crystal Structure*** Bravais Lattice and Laws of Crystallography: Types of solid, Bragg's law of diffraction; Laws of crystallography (Haϋy's law and Steno's law); Permissible symmetry axes in crystals; Lattice, space lattice, unit cell, crystal planes, Bravais lattice. Packing of uniform hard sphere, close packed arrangements (fcc and hcp); Tetrahedral and octahedral voids. Void space in p-type, F-type and I-type cubic systems Crystal planes: Distance between consecutive planes [cubic, tetragonal and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of d_{hkl}; 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. Specific heat of solid: Coefficient of thermal expansion, thermal compressibility of solids; Dulong –Petit's law; Perfect Crystal model, Einstein's theory – derivation from partition function, limitations; Debye's T^3 law – analysis at the two extremes **Practical:** **Experiment 1:** Kinetic study of inversion of cane sugar using a Polarimeter (PreferablyDigital) **Experiment 2:** Study of Phase diagram of Phenol-Water system. **Experiment 3**: Determination of partition coefficient for the	*CO 12.* To define equilibrium and metastable equilibrium *CO 13.* To appreciate the importance of phase rule equation in dealing with heterogeneous equilibrium of different types. *CO 14.* To define Phase rule and understand the concepts number of components, degrees of freedom *CO 15.* To know conditions of equilibrium between two and three phases *CO 16.* To explain the changes expected in the system if we vary temperature or pressure keeping the other variable constant *CO 17.* To understand why normal boiling point and of water normal melting point of ice are 100°C and 0°C respectively *CO 18.* To get an idea how to use the phase diagram in developing practical applications *CO 19.* To understand Clausius-Clapeyron *CO 20.* equation and its applications *CO 21.* To understand and explain miscibility in the solid-state *CO 22.* To gain an understanding of the limitations of classical mechanics at molecular length scales the differences between classical and quantum mechanics the connection of quantum mechanical operators to observables *CO 23.* To see how operator algebra can be

	distribution of I_2 between water and CCl_4 **Experiment 4**: Determination of pH of unknown solution (buffer), by colour matching method **Experiment 5**: pH-metric titration of acid (mono- and di-basic) against strong base **Experiment 6** : pH-metric titration of a tribasic acid against strong base.	used to solve simple eigenvalue problems *CO 24.* To understand the concepts of probabilities, amplitudes, averages, expectation values, and observables *CO 25.* To get an overview about the structure and properties of solid crystals *CO 26.* To know the characterisation of crystals using X-Ray diffraction *CO 27.* To get hands-on experience of phase diagram, partition coefficient, buffer, pH etc
CCH10	**Coordination Chemistry-II** VB description and its limitations. Elementary Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemicalseries.Jahn- Teller distortion.Octahedral site stabilization energy (OSSE).Metal-ligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples). Magnetism and Colour: Orbital and spin magnetic moments,spinonlymomentsofd^nionsandtheircorrelationwitheffective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea). Chemistry of d- and f- block elements **Transition Elements:** General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry. **Lanthanoids and Actinoids:** General Comparison on Electronic configuration, oxidation states, colour, spectral and magnetic properties; lanthanide contraction, separation of lanthanides (ion-exchange method only). **Reaction Kinetics and Mechanism** Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect and its application in complex synthesis, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.	Students will be able to *CO 01.* Explain the basics of Crystal field theory in the light of modern chemistry. *CO 02.* Perceive and narrate the nature of different types of bonding in various inorganic complexes *CO 03.* Interpret and discuss magnetic properties and colour of different complexes in the light of electromagnetochemistry *CO 04.* Perceive and narrate implications of Orgel diagram in understanding the behavior of transition metal complexes. *CO 05.* Explain the properties, electronic configurations and different oxidation states of d and f block elements. *CO 06.* Compare electronic configuration, different oxidation states , spectral and magnetic properties of different Actinoids and Lanthanoids *CO 07.* Prepare different inorganic complexes under laboratory conditions *CO 08.* Use spectrophotometer for studying inorganic complexations and associated. parameters

	Practical: *Inorganic preparations* • $[Cu(CH_3CN)_4]PF_6/ClO_4$ • *Cis*and *trans* $K[Cr(C_2O_4)_2(H_2O)_2]$ • Potassiumdiaquadioxalatochromate(III) • Tetraamminecarbonatocobalt (III)ion • Potassiumtris(oxalato)ferrate(III) • Tris-(ethylenediamine) nickel(II)chloride. • $[Mn(acac)_3]$ and $Fe(acac)_3]$ (acac=acetylacetonate) *Instrumental Techniques* • Measurement of 10Dq by spectrophotometricmethod. • Determination ofλ_{max} of $[Mn(acac)_3]$ and $[Fe(acac)_3]$complexes.	
SEC B	**PHARMACEUTICALS CHEMISTRY** **Drugs & Pharmaceuticals** Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti- inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryltrinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT-Zidovudine). **Fermentation** Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C. **Hands On Practical** 1. Preparation of Aspirin and itsanalysis. 2. Preparation of magnesium bisilicate(Antacid).	The students will develop knowledge about *CO 01.* Drug designing *CO 02.* The synthesis of several drugs e.g., Analgesics Agents, Antipyretic Agents, Anti-inflammatory Agents, Antibiotics Agents, Antifungal Agents, Antiviral Agents, and HIV-AIDS related drugs by adopting the general established method. *CO 03.* Aerobic and anaerobic fermentation *CO 04.* 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. The students will develop hands on experience of *CO 05.* Preparation of Aspirin and its analysis. *CO 06.* Preparation of magnesium bisilicate (Antacid).

Core Courses	Content of CU Syllabus	Course Outcome
Semester 5		
CCH11	**Quantum Chemistry II** **Simple Harmonic Oscillator**: Setting up of One dimensional Schrödinger equation and discussion of solution and wave functions. Classical turning points, Expectation values of x, x^2, p_x and p_x^2 . **Angular momentum**: Commutation rules, quantization of square	Students will learn *CO 01.* To use high-level mathematics as a tool to understand atomic and molecular structure and properties *CO 02.* To understand what is meant by the

	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. Spherical harmonics; Discussion of solution **Hydrogen atom and hydrogen-like ions**: Setting up of Schrödinger equation in spherical polar coordinates, Separation of variables, Solution of angular Part (φ part only), quantization of energy (only final energy expression); Real wave functions. Average and most probable distances of electron from nucleus; Setting up of Schrödinger equation for many-electron atoms (He, Li)Need for approximation methods. Statement of variation theorem and application to simple systems(particle-in- a-box, harmonic oscillator, hydrogen atom). **LCAO** :Born-Oppenheimer approximation. 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.(only wavefunctions, detailed solutionnot required) and their limitations. **Statistical Thermodynamics** **Configuration:**Macrostates, microstates and configuration; calculation with harmonic oscillator; 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, **3rd law:** Absolute entropy, Plank's law, Calculation of entropy, Nernst heat theorem **Adiabatic demagnetization:** Approach to zero Kelvin, adiabatic cooling, demagnetization, adiabatic demagnetization – involvedcurves **Numerical Analysis** Roots of Equation: Numerical methods for finding the roots of equations: Quadratic Formula, Iterative Methods (e.g., Newton Raphson Method). Least-Squares Fitting.NumericalDifferentiation.Numerical Integration(Trapezoidal and Simpson'sRule) **Practical:** Computer programs(Using FORTRAN or C or C ++) based on numerical methods : **Programming 1**: Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weakacid) **Programming 2**: Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas,	orbital concept *CO 03.* To understand the role of rotational and spin angular momenta in chemistry *CO 04.* To Be able to use approximate methods in solving molecular problems *CO 05.* To master molecular orbital theory in diatomic and polyatomic molecules *CO 06.* To understand the connection between common approximation methods and standard chemical frameworks (Born-Oppenheimer approximation, molecular orbitals, for example) *CO 07.* To understand the relationship between microscopic properties of molecules with macroscopic thermodynamic observables *CO 08.* To understand the statistical thermodynamics and various partition functions. *CO 09.* To understand the different aspects of statistical thermodynamics and its applications. *CO 10.* To solve algebraic or transcendental equations using appropriate numerical methods *CO 11.* To approximate a function using an appropriate numerical method *CO 12.* To solve a linear system of equations using an appropriate numerical method *CO 13.* To prove results for numerical root finding methods *CO 14.* To calculate a definite integral using an appropriate numerical method

	Potentiometrictitrations) **Programming 3**: Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values	CO 15. To code numerical methods in Fortran
CCH12	**Carbocyles and Heterocycles** *Polynuclear hydrocarbonsand 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, anthraceneand phenanthrene and their derivatives. *Heterocyclic compounds:*Biological importance of heterocycles referred in the syllabus; 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 approachand mechanistic details): indole: Fischer,quinoline: Skraup, isoquinoline: Bischler- Napieralski synthesis. ***Cyclic Stereochemistry*** *Alicyclic compounds:*concept of I-strain (Baeyer's strain theory); 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. ***Pericyclic reactions*** Mechanism, stereochemistry, regioselectivity in case of Electrocyclic reactions Mechanism, stereochemistry, regioselectivity in case of Cycloaddition reactions Mechanism, stereochemistry, regioselectivity in case of Sigmatropic reactions **Carbohydrates** *Monosaccharides:* Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect	The students will learn about the CO 01. Chemistry of Polynuclear hydrocarbons, Their Types, Structures and several synthetic methods for naphthalene, anthracene and phenanthrene CO 02. Reactions with mechanism ofnaphthalene, anthracene and phenanthrene e.g., sulphonation and bromination with mechanism Students will learn CO 03. Types, Structures, Reactivity, Orientation and General properties of Heterocyclic compounds CO 04. Important synthesis and reactions of furan, pyrrole, Pyridine, indole, quinolinendisoquinolinee.g nitration, Diels alder reaction, polymerisation Students will learn about the CO 05. Cyclic Stereochemistry: Baeyer strain theory, Brief idea about Conformation, Conformational analysis of mono and di-substituted cyclohexane, Optical activity, Nucleophilic substitution (SN1, SN2, NGP) in cyclohexane system etc CO 06. FMO approach involving 4π- and 6π-electrons reactions in thermal and photochemical condition CO 07. FMO approach involving cycloreversion reactions of 4π- and 6π-electrons in thermal and photochemicalcondition CO 08. Diels-Alder reaction CO 09. Photochemical [2+2] cycloadditions CO 10. Sigmatropic shifts and their order; [1,3],[1,5], [3,3] shifts with reference to Claisen and cope rearrangements. The students will develop a concept of CO 11. Types of Carbohydrates

	(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. **Biomolecules *Aminoacids*** synthesis with mechanistic details: Strecker, Gabriel; acetamido malonic ester, azlactone, Bücherer hydantoin synthesis, synthesis involving diketopiperizine, isoelectric point, zwitterions; electrophoresis, reaction (with mechanism): ninhydrin reaction, Dakin-West reaction; resolution of racemic amino acids. **Biomolecules*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 and 'dansyl'methods); partial hydrolysis; specific cleavage of peptides; use of CNBr. **Biomolecules** *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 (Watson-Crick model); complimentary base–pairing in DNA. **Practical:** ***Chromatographic Separations*** 1.TLC separation of a mixture containing 2/3 amino acids 2.TLC separation of a mixture of dyes (fluorescein and methylene blue) 3.Column chromatographic separation of mixture of dyes 4. Paper chromatographic separation of a mixture containing 2/3 amino acids 5.Paper chromatographic separation of a mixture containing 2/3 sugars ***B. Spectroscopic Analysis of Organic Compounds*** Assignment of labelled peaks in the ^{1}H 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	*CO 12.* Differences between Sugar and polysaccharides with Examples *CO 13.* Classifications &Physical and Chemical features of Sugars- Monosaccharides and Oligosaccharides with Examples *CO 14.* Ring structure of monosaccharides (furanose&pyranose forms) *CO 15.* Structure of D-glucose and D-fructose (configuration & conformation) *CO 16.* Definition of anomeric effect, mutarotation, with explanation *CO 17.* Reactions:of aldoses including osazone formation, oxidation, reduction, Stepping–up and Stepping–down of aldoses, Epimerisation *CO 18.* Ring size determination of (+)-glucose by HIO4 *CO 19.* Structure of Disaccharides &Glycosidic linkages, Concept of glycosidic bond *CO 20.* Structure of sucrose & Inversion of cane sugar. *CO 21.* Biomolecules: Synthesis and reactions of Aminoacids, isoelctric point of several different amino acid,electrophoresis *CO 22.* Ninhydrin reaction of amino acids with mechanism, Ninhydrin reaction of proline with mechanism *CO 23.* Definition of Peptides, Peptide linkage formation, Syntheses of peptides using N-protection and using C-protection *CO 24.* Solid phase synthesis Merrifield resin *CO 25.* Peptide sequence: C–terminal and N–terminal unit determination by various methods *CO 26.* Nucleic acids : structures, Structures of pyrimidine and purine bases *CO 27.* Definition of nucleosides and nucleotides corresponding to DNA and RNA with example *CO 28.* The students will be skilled in	

	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: (i) 4□-Bromoacetanilide (ii) 2-Bromo-4'-methylacetophenone (iii) Vanillin (iv) 2□- Methoxyacetophenone (v) 4-Aminobenzoic acid (vi) Salicylamide (vii) 2′- Hydroxyacetophenone (viii) 1,3-Dinitrobenzene (ix) *trans*-Cinnamic acid (x) Diethyl fumarate (xi) 4-Nitrobenzaldehyde (xii) 4′-Methylacetanilide (xiii) Mesityl oxide (xiv) 2-Hydroxybenzaldehyde (xv) 4-Nitroaniline (xvi) 2,3-Dimethylbenzonitrile (xvii) Pent-1-yn-3-ol (xviii) 3-Nitrobenzaldehyde (xix) 3-Aminobenzoic acid (xx) Ethyl 3-aminobenzoate (xxi) Ethyl 4-aminobenzoate (xxii) 3-nitroanisole.	various chromatographic separatation technique *CO 29.* TLC separation of a mixture containing 2/3 amino acids e.g.,L-lysine, L-leucine,D/L- alanine and a mixture of dyes (fluorescein and methylene blue) *CO 30.* Column chromatographic separation of mixture of dyes e.g.,leaf pigments from Spinach Leaves *CO 31.* Paper chromatographic separation of a mixture containing 2/3 amino acids acidse.g.,L- lysine, L-leucine,D/L- alanine and a mixture containing 2/3 sugars e.g., D-(-) Fructose, D-(+) Fructose, Sucrose *CO 32.* Assignment of labelled peaks in the 1H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern. *CO 33.* 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). *CO 34.* The students must record full spectral analysis of compounds from th list given in the syllabus
DSEA	**APPLICATIONS OF COMPUTERS IN CHEMISTRY** **Computer Programming Basics (FORTRAN):** Elements of FORTRAN Language. FORTRAN Keywords and commands, Logical and Relational Operators, iteration, Array variables, Matrix addition and multiplication.Function and Subroutine. *Introduction to Spread sheet Software(MSExcel):* 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.	Students will be able *CO 01.* To get an exposure to the emerging world of computational chemistry *CO 02.* To have a basic idea about computational chemistry calculations *CO 03.* To learn computer based presentation and statistical analysis of data using spreadsheet software applied in the computer labs to solve typical chemical problems, which are taken from the actual research in the theoretical chemistry group.

	Solution of simultaneous equations (for eg: in chemical Equilibrium problems) using Excel **SOLVER** Functions. Use of Excel **Goal Seek** function. Numerical Modelling: Simulation of pH metric titration curves, Excel functions **LINEST** and Least Squares. Numerical Curve Fitting, Regression, Numerical Differentiation and Integration *Statistical Analysis:* Gaussian Distribution and Errors in Measurement and their effect on data sets. Descriptive Statistics using Excel, Statistical Significance Testing, the T test and the F test. Practicals **APPLICATIONS OF COMPUTERS IN CHEMISTRY** (At least 10 experiments are to be performed.) 1. Plotting of Graphs using a spreadsheet. (Planck's Distribution Law, Maxwell Boltzmann Distribution Curves as a function of temperature and molecularweight) 2. Determination of vapour pressure from Van der Waals Equation of State. 3. Determination of rate constant from Concentration-time data using LINEST function. 4. Determination of Molar Extinction Coefficient from Absorbent's data using LINEST function. 5. Determination of concentration simultaneously using Excel SOLVER Function.(For eg: Determination of $[OH^-]$, $[Mg^{2+}]$ and [H3O+] from Ksp and Kw data of Mg(OH)2.) 6. Simultaneous Solution of Chemical Equilibrium Problems to determine the equilibrium compositions from the Equilibrium Constant data at a given Pressure and Temperature. 7. Determination of Molar Enthalpy of Vaporization using Linear and Non Linear Least squares fit. 8. Calculation and Plotting of a Precipitation Titration Curve with MS Excel. 9. Acid-Base Titration Curve using Excel Goal Seek Function. 10. Plotting of First and Second Derivative Curve for pH metric and Potentiometric titrations 11. Use of spreadsheet to solve the 1D Schrodinger Equation(Numerov Method). **12.** Michaelis-Menten Kinetics for Enzyme Catalysis using Linear and Non - Linear Regression	*CO 04.* To use computational tools in his/her studies or later career in academia or private industry. *CO 05.* To perform an error analysis for a given numerical method and their minimization during analysis *CO 06.* To explain Accuracy and precision and their use in practical data or results analysis and errors *CO 07.* To learn to carry out some simple computational chemistry calculations
DSEB	**INORGANIC MATERIALS OF INDUSTRIALIMPORTANCE** **Silicate Industries:** *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	Students will be able to *CO 01.* Examine methodically the physico - chemical properties of different industrial raw materials and asses their suitability in the manufacturing processes , keeping

	glass, fluorosilicate, coloured glass, photosensitive glass. *Ceramics:* Important clays and feldspar, ceramic, their types and manufacture. Hightechnology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre. *Cements:* Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements. *Fertilizers:* 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. *Surface Coatings:* Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings.Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing. *Batteries:* 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. *Alloys:* Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (Arand heat treatment, nitriding, carburizing). Composition and properties of different types of steels. *Catalysis:* 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. *Chemical explosives:* Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX).Introduction to rocket propellants. PRACTICALS 1. Determination of free acidity in ammonium sulphatefertilizer. 2. Estimation of Calcium in Calcium ammonium nitratefertilizer. 3. Estimation of phosphoric acid in superphosphatefertilizer.	in mind the fields of application of those products and byproducts like glasses, ceramics, cements. *CO 02.* Examine methodically the physico chemical properties and manufacturing processes for different chemicals used as fertilizers to find out their suitability for use in the production of different agricultural produce. *CO 03.* Suggest appropriate methods of use of different types of surface coating materials from the angle of their varied physico-chemical properties vis a vis areas of application in the domestic and industrial fields. *CO 04.* Classify different types of batteries used in industries according to their components, functions, applications and suitability. *CO 05.* Classify different types of alloys on the basis of their compositions, properties and scope of use. Narrate the methodology for manufacture of different types of steels in the industry. *CO 06.* Classify different types of catalysts on the basis of their physico-chemical properties. Discuss industrial use of catalyst like zeolite. *CO 07.* Discuss the chemistry of some selected items of explosives and the reasons behind such property of the chemicals. *CO 08.* Analyze systematically the components present in selected chemical compounds and estimate their relative proportions. *CO 09.* Undertake preparation of pigment in the laboratory.

	4. Electroless metallic coatings on ceramic and plasticmaterial. 5. Determination of composition of dolomite (by complexometric titration). 6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or syntheticsamples. 7. Analysis ofCement. 8. Preparation of pigment (zincoxide).	

Core Courses	Content of CU Syllabus	Course Outcome
Semester 6		
CCH13	**Theoretical Principles in Qualitative Analysis** Basic principles involved in analysis of cations and anions and solubility products, commonion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after GroupII. *BioinorganicChemistry* Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, $Fe^{3+}/^{2+}$, $Cu^{2+}/^{+}$, and Zn^{2+}). Metal ion transport across biological membrane Na^{+}/K^{+}-ion pump. Dioxygen molecule in life. Dioxygen management proteins: Haemoglobin, Myoglobin, Hemocyanine and Hemerythrin. Hydrolytic enzymes: carbonate bicarbonate buffering system and carbonic anhydrase and carboxyanhydrase A. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases (examples only) *Organometallic Chemistry* Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.18-electron and 16-electron rules (pictorial MO approach).Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls.pi-acceptor behaviour of CO, synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation, structure, evidences of synergic effect. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertionreactions. *Catalysis by Organometallic Compounds* Study of the following industrial processes 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Hydroformylation	Students will be able to *CO 01.* Explain the basic principle of identification of cations and anions in the mixtures and also the theory involved in the the separation of cations with the removal of interfering anions. *CO 02.* Narrate the basic biochemical reactions in the biological system of some selected metal ions. *CO 03.* Discuss the chemistry of different dioxygen management protein *CO 04.* Narrate the toxic effects of some metal ions. Cite examples of chelation therapy, use of Au and Pt complexes in drug. *CO 05.* Discuss various organometallic compounds with particular reference to their electron arrangements and preparation method and reactions of some important organometallic compounds. *CO 06.* Discuss some important reactions which arecatalysed by some organometallic compounds and their industrial applications. . *CO 07.* Explain the concept of semimicro analysis of different cations and anions and undertake laboratory analysis of mixtures containing various ions

	3. WackerProcess 4. Synthetic gasoline (Fischer Tropschreaction) 5. Ziegler-Natta catalysis for olefinpolymerization. **Practical :** Qualitative semimicro analysis of mixtures containing not more than three radicals. Emphasis should be given to the understanding of the chemistry of different reactions. **Cation Radicals**: Na^+,K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Al^{3+}, Cr^{3+}, Mn^{2+}/Mn^{4+}, Fe^{3+}, Co^{2+}/Co^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Cd^{2+} (Demo), Bi^{3+} (Demo), Sn^{2+}/Sn^{4+}, As^{3+}/As^{5+}, $Sb^{3+/5+}$ (Demo), NH_4^+, Mg^{2+}(Demo). **Anion Radicals**: F^-, Cl^-, Br^-, BrO_3^-, I^-, IO_3^-, SCN^-, S^{2-}, SO_4^{2-}, NO_3^-, NO_2^-,PO_4^{3-}, AsO_4^{3--}, BO_3^{3-}, CrO_4^{2-} / $Cr_2O_7^{2-}$, $Fe(CN)_6^{4-}$, $Fe(CN)_6^{3-}$. **Insoluble Materials**: Al_2O_3(ig), Fe_2O_3(ig), Cr_2O_3(ig), SnO_2, $SrSO_4$, $BaSO_4$, CaF_2, $PbSO_4$.	
CCH14	**Molecular Spectroscopy** Interaction of electromagnetic radiation with molecules and various types of spectra; 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, Diatomic vibrating rotator, P, Q, Rbranches **Electronic Spectroscopy**: Potential energy curves (diatomic molecules), Frank-Condon principle and vibrational structure of electronic spectra; Frank Condon factor. 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; **Raman spectroscopy**: Classical Treatment. Rotational Raman	Students will be able *CO 01.* To develop an elementary idea of spectroscopy and photochemistry *CO 02.* To have a thorough knowledge of the fundamentals of microwave, infra red, Raman and electronic *CO 03.* To discuss the principle and working of spectrophotometer. *CO 04.* To understand the laws of photochemistry *CO 05.* To study the chemistry of surfaces and different types of surface phenomena *CO 06.* To get an idea about the various techniques employed for the characterisation of surfaces *CO 07.* To have a clear concept of the theories of chemical kinetics *CO 08.* To know the general properties of

	effect; Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion *Photochemistry and Theory ofreactionrate:* Lambert-Beer's law: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients; Laws of photochemistry, Stark-Einstein law of photochemical equivalence quantum yield, actinometry, examples of low and high quantum yields Rate of Photochemical processes: Photochemical equilibrium and the differential rate of photochemical reactions, Photostationary state; HI decomposition, H_2-Br_2reaction, dimerisation of anthracene; photosensitised reactions, quenching; Role of photochemical reactions in biochemical processes,chemiluminescence Collision theory of reaction rate (detailed treatment). Lindemann theory of unimolecular reaction; Outline of Transition State theory (classical treatment) Primary Kinetic Salt Effect. *Surface phenomenon* **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); **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); Stability of colloids and zeta potential; Micelle formation *Dipole momentandpolarizability:* 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 Practical: Experiment 1: Determination of surface tension of a liquid using Stalagmometer Experiment 2: Determination of the indicator constant of an acid base indicator spectrophotometrically Experiment 3: Verification of Beer and Lambert's Law for $KMnO_4$ and $K_2Cr_2O_7$ solution Experiment 4: Study of kinetics of $K_2S_2O_8$+KI reaction spectrophotometrically	colloids and macromolecules *CO 09.* To gave hands on experience of surface properties, and spectrophotometry

	Experiment 5: Determination of pH of unknown buffer spectrophotometrically Experiment 6: Determination of CMC of a micelle from Surface Tension Measurement.	
DSEA	**Analytical Methods In Chemistry** **Optical methods of analysis:** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert'slaw. *UV-Visible Spectrometry:* Basic principles of instrumentation (choice of source,monochromator and detector) for single and double beam instrument; *Basic principles of quantitative analysis:* estimation of metal ions from aqueous solution,geometrical isomers, keto-enoltautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method. *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. *Flame Atomic Absorption and Emission Spectrometry:* Basic principles of instrumentation(choice of source, monochromator, 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. *Thermal methodsofanalysis* Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. *Electroanalyticalmethods:* 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. *Separation techniques:* Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.	Analytical Methods In Chemistry The students will be develop a clear concept of *CO 01.* Optical methods of analysis: *CO 02.* UV-Visible Spectrometry *CO 03.* Basic principles of quantitative analysis *CO 04.* Infrared Spectrometry *CO 05.* Flame Atomic Absorption and Emission Spectrometry *CO 06.* Thermal methods of analysis *CO 07.* Electroanalytical methods *CO 08.* Separation techniques: *CO 09.* Solvent extraction: Classification, principle and efficiency of the technique. *CO 10.* Mechanism of extraction: extraction by solvation and chelation *CO 11.* . Technique of extraction: batch, continuous and counter current extractions. *CO 12.* Qualitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. *CO 13.* Quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media *CO 14.* Chromatography: Classification, principle and efficiency of the technique. *CO 15.* Mechanism of separation: adsorption, partition & ion exchange. *CO 16.* Development of chromatograms: frontal, elution and displacement methods. *CO 17.* Qualitative and quantitative aspects of chromatographic methods of

	Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC). Role of computers in instrumental methods of analysis. **PRACTICALS** **Separation Techniques by:** **Chromatography:** **(a)** Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values. **(b)** Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values. **(c)** Chromatographic separation of the active ingredients of plants, flowers and juices by TLC *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. ***I.*** *Analysis of soil:* (i) Determination of pH ofsoil. (ii) Estimation of calcium, magnesium,phosphate ***II.*** *Ionexchange:* Determination of exchange capacity of cation exchange resins and anion exchange resins. ***III.*** *Spectrophotometry* 1. Determination of pKa values of indicator using spectrophotometry. 2. Determination of chemical oxygen demand (COD). 3. Determination of Biological oxygen demand (BOD).	analysis: IC, GLC, GPC, TLC and HPLC. CO 18. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC). CO 19. Role of computers in instrumental methods of analysis. CO 20. The students will be technically guided by the following ways CO 21. Separation Techniques by Chromatography CO 22. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values. CO 23. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values. CO 24. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC CO 25. Separation Techniques by Solvent Extractions CO 26. To separate a mixture of Ni2+& Fe2+ by complexation with DMG and extracting the Ni2+-DMG complex in chloroform, and determine its concentration by spectrophotometry. CO 27. Analysis of soil and determination of pH Estimation of calcium, magnesium, phosphate CO 28. Ion exchange: CO 29. Determination of exchange capacity of cation exchange resins and anion exchange resins. CO 30. Spectrophotometry CO 31. Determination of pKa values of

		indicator using spectrophotometry. *CO 32.* Determination of COD and BOD
DSEB	DSE B-4 : DISSERTATION In a total of 105 lecture hours, a student has to carry out research /review on a topic as assigned by the respective college. A project report and digital presentation will be required for the assessment of the student at the end of the semester.	*CO 01.* To know the role of research as means to more effective decision – making *CO 02.* To familiarize the student with the fundamental concepts and various techniques of research that can be used in Chemistry *CO 03.* To assist students to develop an understanding of the research process and to conduct research leading to successful completion of their dissertation *CO 04.* To assist student to prepare and present their work.