NETAJI SUBHAS OPEN UNIVERSITY

SCHOOL OF SCIENCES

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Detailed Syllabus for B.Sc. in Chemistry Course (NCH) under NEP 2020

Course Code – 5CC-CH- 01 Course Credit – 4

Course Title – Practical Paper–I

Module –I (Inorganic Chemistry)

Unit 1: Method of preparation of standard solutions of titrants
Unit 2: Estimation of carbonate and hydroxide present together in a mixture
Unit 3: Estimation of carbonate and bicarbonate present together in a mixture
Unit 4: Estimation of Fe(II) using $K_2Cr_2O_7$ solution
Unit 5: Estimation of Fe(III) using $K_2Cr_2O_7$ and $KMnO_4$ solution
Unit 6: Estimation of Ca^{2+} using $KMnO_4$ solution
Unit 7: Estimation of Cu^{2+} iodometrically
Unit 8: Estimation of Cr^{3+} using $K_2Cr_2O_7$ solution

Module –II (Organic Chemistry)

Unit-9: Separation of Organic Compounds

Based upon solubility, by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc., of components of a binary solid mixture; purification of any one of the separated components by crystallization and determination of its melting point. The composition of the mixture may be of the following types: Benzoic acid/*p*-Toluidine; *p*-Nitrobenzoic acid/*p*-Aminobenzoic acid; *p*-Nitrotolune/*p*-Anisidine; etc

Unit-10: Determination of boiling point

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

Unit-11: Identification of a Pure Solid Organic Compound by chemical test(s)

Oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid.

Unit-12: Identification of a Pure Liquid Organic Compound by chemical test(s)

Formic acid, acetic acid, methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene.

Unit-13: Organic Preparations

Preparation, purification (only by recrystallization or sublimation), Melting point check and percentage yield calculation of organic compounds using the following reactions:

i. Nitration of aromatic compounds
ii. Condensation reactions
iii. Hydrolysis of amides/imides/esters
iv. Acetylation of phenols/aromatic amines
v. Benzoylation of phenols/aromatic amines
vi. Side chain oxidation of aromatic compounds
vii. Diazo coupling reactions of aromatic amines
viii. Bromination of anilides using green approach (Bromate-Bromide method)
ix. Green 'multi-component-coupling' reaction
x. Selective reduction of m-dinitrobenzene to *m*-nitroaniline

Course Code – 5CC-CH- 02 Course Credit – 4

Course Title – Fundamentals of Chemistry

Module –I : Atoms, Molecules and Their Structure

Unit-1: Subatomic Particles and Rutherford's Model

Units of Measurement; Discovery of electron; Properties of light; Rutherford's experiment and atomic model; Discovery of proton and neutron

Unit-2: Atomic Structure

Atomic Spectra; Bohr's model of atom; Zeeman Effect; Stark Effect; Spin of Electron; Pauli's Exclusion principle; Hund's rule; Primary concept on quantum number

Unit 3: Nuclear Chemistry

Discovery of radioactivity, Notation of sub-atomic particles, Natural radioactivity, Radioactive disintegration theory, Group displacement law, Radioactive series, Transmutation reactions**,**

Module –II : Lights and Molecules

Unit-4: Refraction of Light

Molar refraction and its application; Anomalous results; Molar refractivity of mixtures; Measurement of refractive index; Refractive dispersion

Unit-5: Optical Activity

Plane polarised light; Dextro and Laevo rotation; Measurement of optical rotation; Factors affecting optical rotation; Specific and molar rotation; Optical rotator dispersion

Unit-6: Dipole Moment and Polarisation I

Definition; Induced or distortion polarisation; Orientation polarisation; Total molar polarisation; Polarisability; Clausius – Mossotti Equation; Debye equation (both without derivation)

Unit-7: Dipole Moment and Polarisation II

Measurement of dipole moment; Polarisation and molecular radius; Bond moment and dipole moment; Resonance and dipole moment; dipole moment calculation

Module –III : Fundamentals of Organic Molecules

Unit-8: Electronic Theory of Organic Compounds - I

Inductive effect, Electromeric effect; Conjugation; Resonance; Hyperconjugation

Unit-9: Electronic Theory of Organic Compounds - II

Electrophile and nucleophile; Cleavage of covalent bond; Formation and stability of carbocation, carbanion, and carbon Radical

Unit-10: Nomenclature of Organic Compounds

IUPAC nomenclature rules; Nomenclature of simple & heterocyclic organic compounds

Module –IV: Isomerism of Inorganic Compounds

Unit-11: Isomerism of Inorganic Compounds - I

Structural isomerisation – ionization isomerism, hydrate isomerism, linkage isomerism, ligand isomerism, coordination isomerism, positional isomerism, polymerisation isomerism;

Unit-12: Isomerism of Inorganic Compounds - II

Stereoisomerism - Geometrical isomerism for tetrahedral, square planer, octahedral compounds; Identification of geometrical isomerism; Optical isomerism for tetrahedral, square planer, octahedral compounds

Module –V: Analytical Methods in Chemistry

Unit-13: Methods of Estimation I

Permanganometry, dichromatometry, iodometry, iodimetry, gravimetry, complexometric titration, data and error analysis

Unit-14: Methods of Estimation II

Sörensen's formol method; Titration using Fehling's solution; Bromination (Bromate-Bromide) method; Formalin; Hypobromite method, Saponification method

Course Code – 6CC-CH- 03 Course Credit – 4

Course Title – Practical Paper–II

Module –I: Estimation of ions

Unit 1: Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution
Unit 2: Estimation of Fe(III) and Cu(II) in a given mixture using $K_2Cr_2O_7$ solution
Unit 3: Estimation of Cr(VI) and Mn(II) in a given mixture using $K_2Cr_2O_7$ solution
Unit 4: Estimation of Fe(III) and Cr(VI) in a given mixture using $K_2Cr_2O_7$ solution
Unit 5: Estimation of Fe(II) and Mn(II) in a given mixture using $KMnO_4$ solution
Unit 6: Estimation of Fe(III) and Ca(II) in a given mixture using $KMnO_4$ solution

Module –II: Complexometric Titration

Unit 7: Estimation of Hardness of water
Unit 8: Estimation of Ca(II) and Mg(II) in a mixture
Unit 9: Estimation of Zn(II) and Mg(II) in a mixture

Module –III: Inorganic Preparation

Unit 10: Preparation of Inorganic Metal Complexes

Mohr's salt; Potassium tris(oxalato)chromate(III) trihydrate; Tetraamminecarbonatocobalt(III) nitrate; Potassium bis(oxalato)cuprate(II) dehydrate; Tris(ethylenediamine)nickel(II) chloride

Module –IV: Qualitative Analysis of Organic Compounds

Unit 11: Qualitative Analysis of Single Solid Organic Compounds

i. Detection of special elements (N, S, Cl, Br) by Lassaigne's test
ii. Solubility and classification (solvents: H_2O, 5% HCl, 5% NaOH and 5% $NaHCO_3$)
iii. Detection of the following functional groups by systematic chemical tests:
iv. Aromatic primary amino (Ar-NH_2), aromatic nitro (Ar-NO_2), amido (-$CONH_2$, including imide), phenolic hydroxyl (Ph-OH), carboxylic acid (-COOH), carbonyl (-CHO and >C=O);
v. Melting point of the given compound
vi. Preparation, purification and melting point determination of a crystalline derivative of the given compound
vii. Identification of the compound through literature survey.
viii. 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

Module –V: Quantitative Analysis of Organic Compounds

Unit 12: Quantitative Analysis - I

i. Estimation of glycine by Sörensen's formol method
ii. Estimation of glucose by titration using Fehling's solution
iii. Estimation of sucrose by titration using Fehling's solution

Unit 13: Quantitative Analysis - II

i. Estimation of Vitamin-C (reduced)
ii. Estimation of aromatic amine (aniline) by bromination (Bromate-Bromide) method
iii. Estimation of phenol by bromination (Bromate-Bromide) method

Unit 14: Quantitative Analysis - III

i. Estimation of formaldehyde (Formalin)
ii. Estimation of acetic acid in commercial vinegar
iii. Estimation of urea (hypobromite method)
iv. Estimation of saponification value of oil/fat/ester

Course Code – 6CC-CH- 04 Course Credit – 4

Course Title – Practical Paper–III

Module-1: Kinetic Study of physical parameters

Unit 1: Determination of heat of neutralization of a strong acid by a strong base.
Unit 2: Study of kinetics of acid-catalyzed hydrolysis of methyl acetate.
Unit 3: Study of kinetics of decomposition of H_2O_2.
Unit 4: Determination of partition coefficient for the distribution of I_2 between water and CCl_4.
Unit 5: Verification of Ostwald's dilution law and determination of K_a of weak acid by conductometry.
Unit 6: Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator).
Unit 7: Determination of K_{eq} for $KI + I_2 = KI_3$, using partition coefficient between water and CCl_4; Determination of K_{eq} for acetic acid, using partition coefficient between water and 1-Butanol.
Unit 8: Determination of K_{sp} for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution.

Module-2: Study of physical parameter

Unit 9: Study of viscosity of unknown liquid (glycerol, sugar) with respect to water
Unit 10: Determination of pH of unknown solution (buffer), by color matching method; pH-metric titration of acid (mono-and di-basic) against strong base
Unit 11: Conductometric titration of an acid (strong, weak/ monobasic, dibasic) against strong base
Unit 12: Study of saponification reaction conductometrically.
Unit 13: Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$-solution.
Unit 14: Study of phenol-water phase diagram.
Unit 15: Study of phase equilibrium of a ternary system (Toluene – Acetic Acid – Water)

Course Code – 6CC-CH- 05 Course Credit – 4

Course Title – Inorganic Chemistry – I

Module 1: Atomic Structure

Unit-1: Extra nuclear Structure of atom

Introduction of atomic model, Bohr's model and atomic spectrum of hydrogen, Limitations of Bohr's model and Sommerfeld's modifications, wave mechanics: de Broglie's equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation (without application and solution detail), Significance of ψ and ψ^2,

Unit-2: Idea about Quantum Numbers

Quantum numbers and their significance; Radial and angular wave functions for hydrogen atom (qualitative idea), radial and angular probability distribution curves, shapes of s, p, d and f orbitals (qualitative idea).

Unit 3: Rules of Electronic Configuration & Nuclear Charge

Pauli's exclusion principle, Aufbau principle and limitations, Hund's rules, and multiplicity. Exchange energy, Electronic configurations of atoms; Effective nuclear charge; Shielding and penetration; Slater's rule. Application of Slater's rule

Module II: Nuclear Chemistry

Unit-4: Radioactivity and nuclear chemistry

Atomic nucleus; nuclear stability, n/p ratio and different modes of decay, mass defect, packing fraction and nuclear binding energy. Nuclear forces: Meson exchange theory, elementary idea of nuclear shell model and magic numbers.

Unit-5: Nuclear Reactions

Fission, fusion and spallation reactions, artificial radioactivity, super heavy elements, and their IUPAC nomenclature. Moderators, slow and fast neutrons

Unit 6: Applications of radio-isotopes

Determination of structures, establishment of reaction mechanisms and radio-carbon dating, hazards of radiation and safety measures.

Module III: Periodic Table

Unit-7: Periodic Table

Periodic table, group trends and periodic trends in physical properties. Classification of elements on the basis of electronic configuration. Modern IUPAC Periodic table. General characteristic of s, p, d and f block elements. Position of hydrogen and noble gases in the periodic table.

Unit 8: Chemical periodicity

Atomic radii, ionic radii (Pauling's univalent), covalent radii. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) and factors influencing these properties. Inert pair effect. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements

Unit 9: Chemistry of s-block elements

Li-Na-K, Be-Mg-Ca-Sr-Ba

Unit 10: Chemistry of p-block elements

B-Al-Ga-In-Tl, C-Si-Ge-Sn-Pb, N-P-As-Sb-Bi, O-S-Se-Te, F-Cl-Br-I, He-Ne-Ar-Kr-Xe

Module IV: Redox & Acid Base

Unit-11: Redox Reactions and precipitation reactions

Qualitative idea about complimentary, noncomplimentary, disproportionation and comproportionation reactions, standard redox potentials with sign conventions, Electrochemical series and its application to explore the feasibility of reactions and equilibrium constants, Nernst equation; effect of pH, complexation and precipitation on redox potentials, formal potential;

Unit 12: Basis of redox titration and redox indicators

Redox potential diagrams (Latimer and Frost) of common elements and their applications. Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulphides, carbonates, sulphates and halides.

Unit 13: Acid-Base concept

Arrhenius concept, theory of solvent system (in H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, Lux Flood concept, Lewis's concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Relative strength of acids, Pauling's rules. HSAB principle.

Unit 14: Thermodynamic acidity parameters

Drago-Wayland equation. Superacid, Gas phase acidity and proton affinity. Acid-base equilibria in aqueous solution, Proton transfer equilibria in water, pH, buffer. Acid-base neutralization curves; indicator, choice of indicators.

Course Code – 6CC-CH- 06 Course Credit – 4

Course Title – Organic Chemistry - I

Module-1: Bonding and Physical Properties:

Unit-1: Bonding, Structure and Properties:

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). Inductive effect, field effect, mesomeric effect, resonance energy; bond polarization and bond polarizability; electromeric effect; steric effect, steric inhibition of resonance.

Unit-2: Molecular Orbital Theory

Qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; basic idea about Frontier MOs (FMO); concept of HOMO, LUMO and SOMO; interpretation of chemical reactivity in terms of FMO interactions; sketch and energy levels of π MOs of i) acyclic p orbital system ii) cyclic p orbital system; Frost diagram; elementary idea about α and β; measurement of delocalization energies in terms of β for buta-1,3-diene, cyclobutadiene, hexa-1,3,5-triene and benzene. Hückel's rules for aromaticity up to [10]-annulene; concept of antiaromaticity and homoaromaticity; non-aromatic molecules;

Unit-3: Physical properties of bond:

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

Module-2: General Treatment of Reaction Mechanism:

Unit-4: Mechanistic classification of reaction:

Mechanistic classification: Ionic, radical and pericyclic reaction (only definition and example); addition, elimination and substitution reactions (definition and example); nature of bond cleavage and bond formation: hemolytic and heterolytic bond fission, homogenic and heterogenic bond formation; curly arrow rules in representation of mechanistic steps; reagent type: electrophiles and nucleophiles (elementary idea).

Reaction thermodynamics: Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions.

Unit-5: Reactive intermediates:

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

Unit-6: Concept of organic acids and bases

Effect of structure, substituent and solvent on acidity and basicity; proton sponge; gas-phase acidity and basicity; HSAB principle; application of HSAB in organic chemistry; comparison between nucleophilicity and basicity

Unit-7: Tautomerism

Prototropy, valence tautomerism and ring-chain tautomerism; composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism;

Unit-8: Reaction kinetics

Rate constant and free energy of activation; concept of order and molecularity; free energy profiles; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and secondary kinetic isotopic effect (k_H/k_D); principle of microscopic reversibility; Hammond's postulate.

Module-3: Stereochemistry

Unit-9: Bonding geometries of carbon compounds and representation of molecules:

Tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying-wedge and

Newman projection interaction and their inter translations.

Unit-10: Symmetry Elements and operations:

Concept of chirality and symmetry elements and point groups (Cv, Cnh, Cnv, Cn, Dh, Dnh, Dnd, Dn, Sn (Cs, Ci); molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of epimers; concept of stereogenicity, chirotopicity and pseudoasymmetry; chiral centres and number of stereoisomerism: systems involving 1/2/3-chiral centre(s) (AA, AB, ABA and ABC types).

Unit-11: 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:

Unit-12: 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.

Unit-13: Chirality arising out of stereoaxis

Stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in` allenes, spiro compounds, alkylidene cycloalkanes and biphenyls; related configurational descriptors (Ra/Sa and P/M); atropisomerism; racemisation of chiral biphenyls.

Unit-14: Topicity:

Prostereogenic centre; concept of (pro)n-chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-r and pro-s descriptors of ligands on propseudo asymmetric centre.

Unit-15: Conformational analysis

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; Ethyl halide, 1-halopropane, 1,2-dihaloalkanes, 2,3-dihalobutane, Ethylene glycol, Halo substituted ethanol,

butane2,3-diols (up to four carbons); conformation of conjugated systems (s-cis and s-trans).

Course Code – 6CC-CH- 07 Course Credit – 4

Course Title – Physical Chemistry - I

Module 1: Gaseous and Liquid State of Matter

Unit 1: Gaseous State: Empirical Properties of Gases

Gas Laws -Boyle's law, Charles's law, Gay-Lussac's law, Avogadro's law, Concept of Absolute Temperature; The Equation of State and the Ideal Gas law; Universal Gas Constant; Dalton's law of partial pressure; Graham's law of diffusion; The barometric equation;

Unit 2: Kinetic Theory of Gases - I

Kinetic model of gas – postulates; Velocity of gas molecules; Concept of pressure and temperature from kinetic theory; Derivation of gas laws from kinetic theory; 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

Unit 3: Kinetic Theory of Gases - II

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; Calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and Heat Capacity of gases

Unit 4: Real Gases I

Deviations from Ideal Behavior; Causes of deviation from ideal behaviour; Andrew's and Amagat's plots; van der Waals equation – derivation, features and application in explaining real gas behaviour; Other equation of states

Unit 5: Real Gases II

Compressibility factor, Z, and its variation with pressure and temperature for different gases; Boyle temperature; Critical states; Continuity of States; Critical constants in terms of van der Waals constants; Law of corresponding states; Virial equation of state; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea).

Unit 6: The Liquid State: Surface tension

Surface tension and surface energy**:** definition and explanation; excess pressure, Contact angle, Capillary action, Work of cohesion and adhesion, Vapour pressure over curved surface, Temperature dependence of surface tension, Methods of determination of surface tension;

Unit 7: The Liquid State: Viscosity

General features of fluid flow (laminar flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation (with derivation); Stoke's equation; Effect of temperature and pressure on viscosity; Principle of determination of viscosity coefficient

Module 2: Chemical Thermodynamics - I

Unit8: Basic Concepts and Zeroth Law of Thermodynamics

Thermodynamic terms- intensive & extensive variables, isolated, closed and open systems; Thermodynamic processes- cyclic processes, reversible and irreversible processes; IUPAC convention; Mathematical background - Exact and inexact differential, Partial derivatives, Euler's reciprocity rule, cyclic rule.; Thermodynamic functions (state & path) and their differentials (perfect & imperfect); Zeroth law of thermodynamics, Concept of heat, work & temperature

Unit9: First Law of Thermodynamics

Concept of internal energy and First law of thermodynamics; 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

Unit 10: Thermochemistry

Application of first law of thermodynamics, Laws of thermochemistry, standard state, enthalpy of formation, combustion, solution, dilution (including enthalpy of infinite dilution), neutralization, enthalpy of ionization and formation of ions, bond dissociation energy (calculation from thermochemical data), Born-Haber cycle, Kirchoff's equation

Unit 11: Second Law of Thermodynamics

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 & Clausius statement of second law; Equivalence of the two statements; Carnot's theorem; Thermodynamic scale of temperature; Clausius inequality; Thermodynamic concept of Entropy; Entropy change of systems and surroundings for various processes and transformations; Molecular interpretation of entropy; Entropy and unavailable work

Unit 12: Free Energy Functions

Gibbs free energy (G) & Helmholtz / work function (A) and their significances; Variation of S, G, A with T, V, P; 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; Thermodynamic equations of state

Module 3: Dynamics of Chemical Reactions - I

Unit 13: Chemical Kinetics – Rate Laws

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction; differential and integrated form of rate expressions for zero, first, second and n-th 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. Temperature dependence of rate constant; Arrhenius equation, energy of activation

Unit 14: Chemical Kinetics – Complex Reactions

Rate determining step and steady-state approximation – explanation with suitable examples; kinetics of complex reactions with examples: (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions (iv) chain reactions.

Course Code – 7CC-CH- 08 Course Credit – 4

Course Title – Practical Paper–IV

Module 1: Quantitative analysis

Unit 1: Estimation of available chlorine in bleaching powder using iodometry
Unit 2: Estimation of available oxygen in pyrolusite using permanganometry
Unit 3: Estimation of Cu in brass using iodometry
Unit 4: Estimation of Fe in cement using permanganometry
Unit 5: Estimation of chloride gravimetrically
Unit 6: Estimation of Ni(II) using DMG gravimetrically
Unit 7: Paper chromatographic separation of Ni(II) and Co(II)
Unit 8: Measurement of $10D_q$ by spectrophotometric method
Unit 9: Preparation of $Mn(acac)_3$ and determination of its λ_{max} colorimetrically

Module 2: Qualitative semimicro analysis

Unit 10: Qualitative Analysis of Organic Compounds

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

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

Acid Radicals: Cl^-, Br^-, I^-, S^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, SCN^-, NO_3^-, NO_2^-, BO_3^{3-}, PO_4^{3-}, AsO_4^{3-} and H_3BO_3

Insoluble Materials: Cr_2O_3, Fe_2O_3, Al_2O_3, SnO_2, $PbSO_4$, $BaSO_4$, $SrSO_4$

Module 3: Chromatographic Separations

Unit 11: TLC separation of a mixture containing 2/3 amino acids
Unit 12: Column chromatographic separation of mixture of dyes
Unit 13: Paper chromatographic separation of a mixture containing 2/3 sugars

Module 4: Spectroscopic Analysis of Organic Compounds

Unit 14: Spectroscopic Identification and Analysis
Assignment of labelled peaks in the ^1H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.
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).
The students must record full spectral analysis of at least 15 (fifteen) compounds from the following list:

i) 4-Nitroaniline, ii) 2-Bromo-4'-methylacetophenone, iii) Vanillin, iv) 2-Methoxyacetophenone, v) 4-Aminobenzoic acid, vi) Pent-1-yn-3-ol, vii) 2-Hydroxyacetophenone, viii) 1,3-Dinitrobenzene, ix) Benzylacetate, x) 2-Hydroxy-3-nitrobenzaldehyde xi) 3-Ethoxy-4-hydroxybenzaldehyde, xii) 4-Nitrobenzaldehyde, xiii) Ethyl 4-aminobenzoate, xiv) 2-Methoxybenzaldehyde, xv) 2-Hydroxybenzaldehyde, xvi) Ethyl-3-aminobenzoate , xvii) 2,3-Dimethylbenzonitrile, xviii) 3-Aminobenzoic acid, xix) Methyl 3-hydroxybenzoate

Course Code – 7CC-CH- 09 Course Credit – 4

Course Title – Practical Paper–V

Module 1: Determination of physical parameter

Unit 1: Determination of surface tension of a liquid using Stalagmometer.

Unit 2: Determination of CMC from surface tension measurements.
Unit 3: Verification of Beer and Lambert's Law for $KMnO_4$ and $K_2Cr_2O_7$ solution.
Unit 4: Study of kinetics of $K_2S_2O_8$ + KI reaction, spectrophotometrically.
Unit 5: Determination of pH of unknown buffer, spectrophotometrically.
Unit 6: Spectrophotometric determination of CMC
Unit 7: pH-metric titration of monobasic and dibasic acids / bases
Unit 8: Determination of pka of an indicator using spectrophotometry

Module 2: Polymer Synthesis

Unit 9: Free radical solution polymerization of styrene (St)/Methyl Methacrylate (MMA)/Methyl Acrylate (MA) / Acrylic acid (AA).
Unit 10: Purification of monomer Polymerization using benzoyl peroxide (BPO)/2,2'-azo-bis-isobutylonitrile (AIBN)
Unit 11: Preparation of nylon66/6
Unit 12: Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
Unit 13: Redox polymerization of acrylamide
Unit 14: Precipitation polymerization of acrylonitrile
Unit 15: Preparation of urea-formaldehyde resin
Unit 16: Preparations of novalacresin / resoldresin
Unit 17: Microscale Emulsion Polymerization of Poly(methylacrylate)

Course Code – 7CC-CH- 10 Course Credit – 4

Course Title – Inorganic Chemistry -II

Module I: Chemical Bonding & Crystal Structure

Unit-1 Ionic Bond
Lattice energy, Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy, Born-Haber cycle and its applications,

Unit-2: Co-valence and structure:

Polarizability of ions, Fajan's rules and its applications, radius ratio rules – its applications and limitations, solvation energy and solubility energetics of dissolution process;

Unit 3: Crystal structure:

Packing in crystals, voids in crystal lattice, packing efficiency, Structure of ionic solids: rock salt, zinc blende, wurtzite, fluorite, antifluorite, perovskite and layer lattice. Stoichiometric and non-stoichiometric crystal defects.

Unit-4: Covalent Bond

Lewis structures, formal charge; Qualitative idea of V.B. Theory, directional properties of covalent bond, Concept of Equivalent and nonequivalent Hybridization and shapes of simple molecules and ions (examples from main groups),

Unit-5: Stereochemically non-rigid molecules
Berry's pseudorotation, Resonance and Dipole moments of inorganic molecules and ions, VSEPR theory and Bent's rule and their applications

Module II: Molecular Orbital Theory, Metallic Bonding & Weak Chemical Forces

Unit-6: Molecular orbital theory -I

MOT (elementary idea), Theory (elementary pictorial approach), concept of bond order, MO diagram of homo-nuclear diatomic (1st and 2nd period elements), Homonuclear Molecules with MOs Originating from s Orbitals,

Unit-7: Molecular Orbital Theory -II

Homonuclear Molecules with MOs Originating from s and p Orbitals, Heteronuclear Diatomic Molecules, σ and π bonding in octahedral complexes (a pictorial approach), hetero-nuclear diatomic (HF, CO, NO, NO^+ and CN^-) and triatomics (H_2O and BeH_2)

Unit-8: Metallic Bond

Electron sea model and elementary idea about band theory, classification of inorganic solids and their conduction properties according to band theory;

Unit-9: Weak Chemical Forces

Non-covalent forces, Hydrogen bonding: classifications, its effect on the properties of compounds and its importance in biological systems, van der Waal's forces

Module III: Coordination Chemistry

Unit-10: Basics of coordination chemistry

Werner's theory, EAN rule, classification of ligands and their binding modes, IUPAC nomenclature of coordination compounds (up to two metal centres), overall and stepwise stability constants, chelates, inner metallic complexes, crown ethers

Unit-11: Stereochemistry of Coordination Compounds

Stereochemistry and isomerism (constitutional, stereo and optical) of complexes with coordination no. 4 and 6. Idea about double salts and complex salts,

Unit-12: Valence bond theory and crystal field theory

Structure and bonding of coordination compounds based on V.B. Theory and its limitations. Elementary idea about CFT, splitting of d^n configuration in ML_4 to ML_6 systems, factors affecting, spectrochemical series of ligands, CFSE in weak and strong fields,

Module IV: Electronic Spectra & Inorganic Reaction Mechanism

Unit-13: Electronic spectra of complexes

Colour and electronic spectra of complexes: selection rules for electronic transitions, d-d transition, charge transfer transition (qualitative idea), L-S coupling and R-S ground state term for atomic no. up to 30, qualitative ORGEL diagram for $3d^1$ – $3d^9$ ions with appropriate symbols for the energy levels.

Unit-14: Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms, substitution reactions in square planar complexes; *trans*-effect - theories and applications; lability and inertness in octahedral complexes towards substitution reactions. Elementary concept of *cis*-effect

Course Code – 7CC-CH- 11 Course Credit – 4

Course Title – Organic Chemistry -II

Module-1: Chemistry of alkenes and alkynes:

Unit-1: Chemistry of alkenes:

Structure and reactivity of alkenes, regioselectivity of electrophilic addition reaction of alkenes (Markownikoff and anti-Markownikoff additions); reactions of alkenes namely hydrogenation, halogenations, hydrohalogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation, epoxidation, syn and anti-hydroxylation, ozonolysis, addition of singlet and triplet

carbenes; electrophilic addition to conjugated diene; radical addition: Halolactonisation, Birch reduction of benzenoid aromatics; interconversion of E - and Z - alkenes;

Unit-2: Chemistry of alkynes

Structure of alkynes, reactivity of alkynes, reactions of alkynes namely hydrogenation, halogenations, hydrohalogenation, hydration, Addition of borane: hydroboration-oxidation, reactions of terminal alkynes by exploring its acidity; interconversion of terminal and non-terminal alkynes.

Module-2: Chemistry of Carbonyl and Related Compounds

Unit-3: Addition to carbonyl compounds:

Structure, properties, reactivity and preparation of carbonyl compounds; Addition reaction of carbonyl compounds, Burgi-Dunitz trajectory in nucleophilic additions; formation of hydrates, cyanohydrins, HCl addition, and bisulphite adduct; nucleophilic addition-elimination reactions with alcohols, thiols and nitrogen- based nucleophiles;

Unit-4: Reactions involving carbonyl group:

Benzoin condensation, Cannizzaro and Tischenko reactions, Wittig and Corey-Chaykovsky reaction; Rupe rearrangement, Clemmensen, Wolff-Kishner, reductions with LiAlH4, NaBH4, Bouveault-Blanc reduction, MPV reduction, Oppenauer oxidation, acyloin condensation

Unit-5: Exploitation of acidity of α-H of carbonyl compounds:

Acidities of α-H of carbonyl compounds, Formation of enols and enolates; kinetic and thermodynamic enolates; α-halogenation of carbonyl compounds, Haloform reaction, Hell-Volhard-Zelinsky (H.V.Z.) reaction, SeO2 oxidation; Aldol condensations, Knoevenagel condensation, reaction, Claisen-Schmidt reaction, Dieckmann reaction, Mannich reaction, Perkin reaction, Favorskii rearrangement; Claisen condensation,

Unit-6: Ester hydrolysis:

Hydrolysis at sp^2 carbon (C=O system), Different types of ester hydrolysis with Mechanism: B_{AC}^2 Mechanism, A_{AC}^2 Mechanism, A_{AC}^1 Mechanism, B_{AL}^1 Mechanism, A_{AL}^1 Mechanism;

Module-3: Nitrogen Compounds and Organometallics

Unit-7: Amines:

Preparation of aliphatic & aromatic amines by different methods, separation and identification (Hinsberg's method) of primary, secondary and tertiary amines; reaction with mechanism: reaction with nitrous acids, Eschweiler–Clarke methylation, diazo coupling reaction, Mannich reaction; formation and reactions of phenylene diamines, diazomethane and diazoaceticester.

Unit-8: Nitro compounds:

Preparation of aliphatic and aromatic nitro compounds: Reactions of nitro compounds involving reduction under different conditions; Neff carbonyl synthesis, Henry reaction and conjugate addition of nitroalkane anion.

Unit-9: Alkylnitrile and isonitrile:

Preparation of alkyl nitrile and isonitrile compounds, reaction of alkyl nitrile and isonitrile involving Thorpe nitrile condensation, von Richter reaction.

Unit-10: Diazonium salts and their related compounds:
Preparation and Reactions of Diazonium salts involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp - Klingermann.

Unit-11: Organometallics:
Preparation and reactions of Grignard reagent; synthetic use of Grignard reagent involving addition to carbonyl compounds; substitution on -COX; abnormal behavior of Grignard reagents; Metal alkyls, Reformatsky reaction; Blaise reaction; organocopper reagents; Corey-House synthesis

Module-4: The Logic of Organic Synthesis:

Unit-12: Retrosynthetic analysis:
Definitions of some terms used in retrosynthesis: Disconnections; synthons, donor and acceptor natural reactivity and umpolung; functional group interconversion and addition (FGI and FGA); Guidelines for choosing retrosynthesis, synthons and synthetic equivalents: latent polarity in bifunctional compounds: consonant and dissonant polarity; illogical electrophiles and nucleophiles; Retrosynthetic analysis, C-C disconnections and synthesis: one-group and two-group disconnection (1,2-, 1,3- and 1,5-dioxygenated compounds), Umpolung strategies, reconnection of 1,6-dicarbonyl compounds;

Unit-13: Protection-deprotection and Strategy of ring synthesis
Protecting groups for carbonyl compounds**,** alcohol, amine, carbonyl, acid. Strategy of ring synthesis: thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique.

Unit-14: Asymmetric synthesis:
stereoselective and stereospecific reactions; diastereoselectivity and enantioselectivity (only definition); enantioselectivity: kinetically controlled MPV reduction; diastereoselectivity: addition of nucleophiles to C=O adjacent to a stereogenic centre: Felkin-Anh and Zimmermann-Traxler models

Course Code – 7CC-CH- 12 Course Credit – 4

Course Title – Physical Chemistry -II

Module 1: Chemical Thermodynamics - II

Unit 1: System of Variable Composition

Partial properties and chemical potential: Chemical potential and activity, partial molar quantities, relation between chemical potential and Gibb's free energy and other thermodynamic state functions; variation of chemical potential (μ) with temperature and pressure; Gibbs-Duhem equation; fugacity and fugacity coefficient; Variation of thermodynamic functions for systems with variable composition; Standard states; Equations of states for these systems

Unit 2: Nernst Heat theorem and Third Law of Thermodynamics

Thermodynamic probability, entropy and probability; Nernst Heat Theorem; Statement of third law, unattainability of absolute zero, calculation of absolute entropy of molecules, concept of residual entropy, Approach to zero Kelvin, adiabatic cooling, demagnetization, adiabatic demagnetization – involved curves.

Module 2: Application of Thermodynamics - I

Unit 3: Chemical Equilibrium I

Criteria of thermodynamic equilibrium; Degree of advancement of reaction; van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; expression of equilibrium constants (Kc, Kp and Kx); Reaction quotient and Gibbs free energy; Equilibrium constants and their dependence on temperature, pressure and concentration; Van't Hoff's reaction isobar and isochors from different standard states

Unit 4: Chemical Equilibrium II

Le Chatelier's principle and its derivation; variation of equilibrium constant under different conditions – temperature, pressure and addition of inert gas; Industrial application of Le Chatelier's principle; Heterogeneous equilibrium; Nernst's distribution law and its application; (finding out Keq using Nernst distribution law for $KI+I_2 = KI_3$ and dimerization of benzene.

Unit 5: Solutions I

Different types of solutions; Expression of concentration of solutions; Solution of gases in gases: Chemical potential and other thermodynamic functions of an ideal gas in an ideal gas mixture; Solution of gases in liquids; Henry's law and it's thermodynamic derivation; Effect of temperature on solubility of gases; Solutions of solids in liquids

Unit 6: Solutions II

Solution of liquids in liquids; Raoult's Law; Vapour pressure curves and deviation from Raoult's law; Duhem-Margules Equation; Ideal solution and Chemical potential of a component in an ideal mixture; Azeotropic solution; Vapour pressure composition diagram; Konowaloff's rule; Boiling point – composition diagram; Principle of fractional distillation;

Unit 7: Solutions III

Partially miscible liquids pairs; Phenol water system; Upper and lower Critical solution temperature; Immiscible liquid pairs; Steam distillation; Three component systems, water-chloroform-acetic acid system, triangular plots;

Unit 8: 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.

Module 3: Ionic Equilibrium

Unit 9: Ionic Equilibrium - I

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, dissociation constants of mono and diprotic acids;

Unit 10: Ionic Equilibrium - II

Chemical potential of an ion in solution; Activity and activity coefficients ofions in solution; Ionic strength; Debye-Huckel limiting law; brief qualitative description of the postulates involved, qualitative idea of the model, the equation (without derivation) for ion-ion atmosphere interaction potential.; Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law; Derivation of mean ionic activity coefficient from the expression of ion-atmosphere interaction potential; Applications of the equation and its limitations

Unit 11: Ionic Equilibrium - III

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts; Sparingly soluble electrolytes; Solubility product; Mean ionic activity coefficient; Solubility, activity coefficients, non-common ion effect, Common ion effect;

Unit 12: Buffers and Neutralisation

Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action, examples and uses; Qualitative treatment of acid– base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations

Module 4: Electrochemistry -I

Unit 13: Electrolytic Conductance I

Arrhenius theory of electrolytic dissociation; Conductance and measurement of conductance, cell constant, conductivity, equivalent conductivity and molar conductivity; Variation of conductivity and equivalent conductivity with dilution for true and potential electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductivity at infinite dilution and their determination for strong and weak electrolytes

Unit 14: Electrolytic Conductance II

Debye-Hückel-Onsager equation, Asymmetric effect and Electrophoretic effect Wien effect, Debye-Falkenhagen effect, Walden's rule. Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, Ostwald dilution law

Unit 15: Electrolytic Conductance II

Determination of transference number using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii)solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, (v) hydrolysis constants of salts

Course Code – 7CC-CH- 13 Course Credit – 4

Course Title – Inorganic Chemistry -III

Module I: d-block & f-block elements

Unit 1: d-block elements:
Characteristic properties, Comparison among the p-and d-block and the elements of 3d series with reference to electronic configuration, ionization energy, oxidation states and E^0 values; magnetic properties

Unit 2: f-block elements:

Comparison between d and f-block elements; Electronic configuration, oxidation states, variation of magnetic properties (Ln^{3+}), atomic and ionic (3+) radii of lanthanides; consequences of lanthanide contraction, separation of lanthanides by ion exchange and solvent extraction methods; comparison between lanthanides and actinides.

Module II: Symmetry & Magnetochemistry

Unit-3: Molecular symmetry

Symmetry as a universal theme, concept of symmetry elements and operations (with examples); symmetry properties of atomic orbitals (s, p and d);

Unit-4: Point group:

Concept of point groups, identification of molecular point groups in some simple molecules and ions; applications of symmetry for polarity and chirality.

Unit-5: Concept of Magnetochemistry

Classification of magnetic substances, Origin of para magnetic moments, temperature dependence of paramagnetism – Curie and Curie-Weiss law, TIP, magnetic susceptibility and its measurement (Gouy method), diamagnetic correction, effective magnetic moment,

Unit 6: Advance magnetochemistry:

spin only moment for 3d metals, Orbital contribution to magnetic moment, spin-orbit coupling, quenching of orbital contribution, Sub-normal magnetic moments and antiferromagnetic interactions (elementary idea with examples).

Module III: Essential Elements, Toxic Elements & Organometallic Chemistry

Unit 7: Essential Elements of Bio-inorganic Chemistry

Essential elements of life, Role of metal ions in living systems- a brief review, Elementary idea about proteins, enzymes and ionophores; Structure of ATP, Na^+ ion pump and transport of Na^+ and K^+ across cell membrane; biological nitrogen fixation.

Unit 8: Toxic Heavy Metals

toxic metals (Pb, Cd and Hg) and their effects, As-toxicity, Wilson disease, chelation therapy; platinum and gold complexes as drugs (examples only).

Unit 9: Organometallic Chemistry

Definition, Classification of organometallic compounds, hapticity of ligands, nomenclature, 16-electron & 18-electron rule and its applications; preparation and structure of mono- and bi-nuclear carbonyls of 3d series, synergic effect of CO and use of IR data to explain extent of back bonding

Unit 10: Organometallic reactions & Compounds

General methods of preparation of metal-carbon σ-bonded complexes, Zeise's salt, Metal-carbon multiple bonding; Preparation, structures, properties and reactions of ferrocene; elementary idea about oxidative addition, reductive elimination, insertion reactions;

Module IV: Catalysis, Metalloenzymes, Metalloproteins & Coordination Polymer, Advance Coordination Chemistry

Unit 11: Catalysis:

Study of the following catalytic processes: alkene hydrogenation (Wilkinson's catalyst), hydroformylation, Wacker process, Synthetic gasoline (Fischer Tropsch reaction) and Olefin polymerization reaction (Ziegler-Natta catalyst)

Unit 12: Metalloenzymes and metalloproteins:

Active site structures and bio-functions of haemoglobin, myoglobin, carboxy peptidase A, carbonic anhydrase B, cytochrome c, ferredoxins and chlorophyll.

Unit 13: Coordination polymer:

Inorganic polymer and coordination polymer, binding ligands (N^{3-}, SCN^{-}, X^{-}, dicarboxylates, 4, 4-bipyridine, pyrazine, 4 pyridine-4-carboxylic acids,), 1D Chain, 2D-sheet, 3D-structure, non-covalent interactions, polysilicates, polyphosphates, polyhalides, [PNX_2], S-polymers .

Unit 14: Advance co-ordination Chemistry:

OSSE, High spin and low spin complexes, spin isomerism, tetragonal distortion, Jahn Teller theorem and applications, achievements, and limitations of CFT, nephelauxetic effect, stabilization of unusually high and low oxidation states of 3d series elements,

Course Code – 7CC-CH- 14 Course Credit – 4

Course Title – Organic Chemistry -III

Module-1: Substitution and Elimination Reactions:

Unit-1: Substitution reaction:

Free-radical substitution reaction: Halogenation of alkanes, mechanism and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.

Nucleophilic substitution reactions: substitution at SP3centre: mechanisms, relative rates & stereochemical features: SN1, SN2, SN2', SN1' and SNi; effects of solvent, substrate structure,

leaving group and nucleophiles; substitutions involving NGP; role of crown ethers and phase transfer catalysts in substitution reaction

Unit-2: Elimination reactions:

E1, E2, E1cB and Ei (pyrolytic syn eliminations) reaction; formation of alkenes and alkynes; mechanisms, reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination; importance of Bredt's rule relating to the formation of C=C.

Unit-3: Aromatic Electrophilic Substitution:

Mechanisms and evidences of aromatic Electrophilic Substitution; orientation and reactivity; Different aromatic electrophilic reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; Reaction involving one-carbon electrophiles: chloromethylation, Gatterman-Koch, Gattermann, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt; Ipso substitution.

Unit-4: Aromatic Nucleophilic Substitution:

Example, Mechanisms (with evidences) of aromatic Nucleophilic Substitution reaction; Bimolecular mechanism, SN1 mechanism, Addition-elimination mechanism and evidences in favor of it; cine substitution (benzyne mechanism), structure of benzyne.

Module-2: Rearrangements:

Unit-5: Rearrangement to electron-deficient carbon:

Wagner-Meerwein rearrangement, Pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, Benzil- Benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement.

Unit-6: Rearrangement to electron-deficient nitrogen:

rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann.

Unit-7: Rearrangement to electron-deficient oxygen:

Baeyer-Villiger oxidation, cumene hydroperoxide-phenol rearrangement and Dakin reaction.

Unit-8: Aromatic rearrangements:

Migration from oxygen to ring carbon: Fries rearrangement and Claisen rearrangement. Migration from nitrogen to ring carbon: Hofmann-Martius rearrangement, Fischer-Hepp rearrangement, Bamberger rearrangement, Orton rearrangement and benzidine rearrangement.

Module-3: Carbohydrates

Unit-9: Monosaccharides:

Carbohydrates, Classification of Carbohydrates, Reducing and Non-reducing Sugar, The D and L Notation, Configuration of the Aldoses, Structure of D-glucose & D-fructose; ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect; mutarotation; reactions involving Fischer glycosidation, osazone formation, bromine-water oxidation, HNO_3 oxidation, epimerization, 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 ; Interconversion of ketose into isomeric aldose, Fischer's proof of configuration of (+)-glucose.

Unit-10: Polysaccharides:

Disaccharides: Glycosidic linkages, concept of glycosidic bond formation by glycosyl donor-acceptor; structure of sucrose, inversion of cane sugar. Polysaccharides: Starch (structure and its use as an indicator in titrimetric analysis). Functions of carbohydrates

Module-4: Organic Spectroscopy:

Unit-11: UV Spectroscopy:

Introduction; types of electronic transitions, Principles of absorption spectroscopy: Beer's and Lambert's Law, transition dipole moment and allowed/forbidden transitions; chromophores and auxochromes; Bathochromic and Hypsochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); application of Woodward's Rules for calculation of $\lambda_{max}$for the following systems: conjugated diene, α,β-unsaturated carbonyl compounds, Factors affecting positions of λ_{max} considering conjugative effect, steric effect, solvent effect, effect of pH; effective chromophore concentration: keto-enol systems; benzenoid transitions.

Unit-12: IR Spectroscopy:

Introduction; modes of molecular vibrations (fundamental and non- fundamental); Application of Hooke's law and force constant, IR active molecules; fingerprint region and its significance; vibrational coupling in IR; Fermi resonance, factors affecting stretching frequencies: effect of conjugation, electronic effects, mass effect, bond multiplicity, ring- size, solvent effect, H-bonding on IR absorptions; Some characteristic and diagnostic stretching & bending frequencies of C-H, N-H, O-H, C-O, C-N, C-X, C=C, C=O, C=N, N=O, C≡C, C≡N; application in functional group analysis.

Unit-13: NMR Spectroscopy:

Introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic

Resonance; Precessional Motion, Resonance, Chemical shift, Internal standard, equivalent and non-equivalent protons; Shielding and deshielding effect, 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); source of spin-spin coupling, Multiplicity in Proton NMR, Coupling constants, NMR peak area, Chemical exchange (proton exchange reaction) Interpretation of NMR spectra of simple compounds.

Unit-14: Applications of Spectroscopy:

Strategy for the Structure Elucidation of the Organic Compounds by Combined Use of UV, IR, NMR and Mass Spectral Data.

Course Code – 7CC-CH- 15 Course Credit – 4

Course Title – Physical Chemistry -III

Module 1: Heterogeneous Equilibrium

Unit 1: Phase Equilibrium

Definitions of phase, component, and degrees of freedom; Conditions of phase equilibrium; Phase rule and its derivation; First order phase transition and Clapeyron equation; Clausius-Clapeyron equation -derivation and use; Ehrenfest Classification of phase transition

Unit 2: Phase Diagram – One Component Systems

Definition of phase diagram; Phase diagram of water, carbon dioxide and sulfur – diagram, detailed discussions, features; application of phase rule

Unit 3: Phase Diagram – Two Component Systems

Application of phase rule to two component systems; Types of two components condensed systems; Simple Eutectic systems – Phase diagrams; Deep eutectics; Solid liquid phase diagrams with components having congruent and incongruent melting points; Freezing mixtures

Module 2: Quantum Chemistry - I

Unit 4: Dawn of Quantum Mechanics

Black body radiation; Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (without proof)

Unit 5: Quantum Mechanics - Postulates

Postulates of Quantum Mechanics, Schrodinger time-independent equation; nature of the equation, acceptability conditions for the wave functions and probability interpretations of wave function Orthonormality of wave function

Unit 6: Concept of Operators

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

Unit 7: The Particle in a Box Problem

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 level

Unit 8: Simple Harmonic Oscillator

Setting up of One-dimensional Schrödinger equation and discussion of solution and wave functions. Classical turning points, Expectation values x, x^2, p_x and p_x^2

Module 3: Electrochemistry -II

Unit 9: Electromotive forces I

Quantitative aspects of Faraday's laws of electrolysis; 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.

Unit10: Electromotive forces II

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 glass electrodes

Unit11: Electromotive forces III

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers; potentiometric titrations (acid-base, redox, precipitation); Brief descriptions of electrochemical power sources; primary, secondary, Lithium batteries and fuel cells

Unit 12: Electromotive forces IV

Polarization and overvoltage phenomena, Activation polarization; basics of activation-controlled reactions, Tafel Equation. Preliminary ideas of cyclic voltammetry, corrosion and inhibition of corrosion and electroplating, applications of electrolysis in metallurgy and industry

Module 4: Dynamics of Chemical Reactions - II

Unit 13: Chemical Kinetics – Theory of reaction rates

Collision theory of reaction rate (detailed treatment); Lindemann theory of unimolecular reaction; Outline of Transition State theory (classical treatment); Primary Kinetic Salt Effect;

Unit 14: Catalysis

Types of catalyst, specificity and selectivity, Homogeneous catalysis with reference to acid-base catalysis; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number

Course Code – 8CC-CH- 16 Course Credit – 4

Course Title – Polymer Chemistry

Module I : Fundamentals of Polymer Chemistry

Unit-1: Introduction and history of polymeric materials

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

Unit-2: Functionality and its importance

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

Unit-3: Kinetics of Polymerization

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations.

Unit-4: Crystallization and crystallinity

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Unit-5: Nature and structure of polymers

Structure Property relationships.

Unit-6: Determination of molecular weight of polymers

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

Unit-7: Glass transition temperature (Tg) and determination of Tg

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

Unit-8: Polymer Solution

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Lower and Upper critical solution temperatures.

Module II : Properties of Polymers

Unit-9: Properties of Polymer -I

(Physical, thermal, Flow & Mechanical Properties) Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers,

Unit-10: Properties of Polymer -II

Polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Module III : Composite Materials

Unit-11: Composite materials-I

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites,

Unit-12: Composite materials-II

Polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

Unit-13: Specialty polymers:

Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrole, applications of conducting polymers, Ion-exchange resins and their applications.

Unit-14: Ceramic & Refractory:

Introduction, classification, properties, raw materials, manufacturing, and applications.

Course Code – 8CC-CH- 17 Course Credit – 4

Course Title – Practical Paper–VI

Module-I: Green Chemistry

Unit-1: Safer starting materials

Preparation and characterization of nanoparticles of gold using tea leaves.

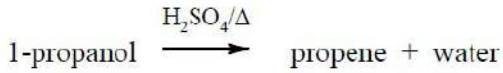
Unit-2: Avoiding waste

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.

Preparation of propene by two methods can be studied

Triethylamine ion + OH-⟶ propene + trimethyl propene + water



Other types of reactions, like addition, elimination, substitution, and rearrangement should also be studied for the calculation of atom economy.

Unit-3: Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

Unit-4: Alternative Green solvents

Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice. Mechanochemical solvent free synthesis of azomethines

Unit-5: Alternative sources of energy

Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II). Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Module-II (Analytical & Industrial chemistry)

Unit-6: Separation Techniques - Chromatography

Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the RF values.

Unit-7: 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.

Analysis of soil: Determination of pH of soil. Total soluble salt Estimation of calcium, magnesium, phosphate, nitrate Ion exchange: Determination of exchange capacity of cation exchange resins and anion exchange resins.

Unit-8: Determination of Oxygen Demand

Determination of chemical oxygen demand (COD); Determination of Biological oxygen demand (BOD)

Unit-9: Determination of free acidity in ammonium sulphate fertilizer.
Unit-10: Estimation of Calcium in Calcium ammonium nitrate fertilizer.

Unit-11: Estimation of phosphoric acid in super phosphate fertilizer.
Unit-12: Determination of composition of dolomite (by complexometric titration).
Unit-13: Analysis of (Cu,Ni);(Cu,Zn) in alloy or synthetic samples.

Unit-14: Analysis of Cement.

Course Code – 8CC-CH- 18 Course Credit – 4

Course Title – Inorganic Chemistry IV

Module – I: Analytical Chemistry

Unit-1: Qualitative and quantitative aspects of analysis

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

Unit-2: Optical methods of analysis

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. ii. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator, and detector) for single and double beam instrument, Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument, Flame Atomic Absorption and Emission Spectrometry

Unit-3: Thermal methods of analysis

Theory of thermogravimetry (TG), instrumentation. Composition determination of Ca and Mg from their mixture.

Unit-4: Electroanalytical methods

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

Unit-5: Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of

extraction: extraction by solvation and chelation,

Unit 6: Application of Solvent Extraction

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media, separation of Fe^{3+} and $Cu^{3+}$from a mixture.

Unit 7: 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.

Module-II: Industrial Chemistry

Unit-8: Silicate Industries

i. Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armored glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

ii. Ceramics: Important clays and feldspar, ceramic, their types, and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fiber.

iii. Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Unit-9: 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.

Unit-10: Surface Coatings

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Pigments, toners and laker pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Water and Oil paints, additives, Metallic coatings (electrolytic and electroless)

Unit-11: 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

Unit-12: 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). Composition and properties of different types of steels.

Unit-13: Industrial 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.

Unit-14: Chemical explosives

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

Course Code – 8CC-CH- 19 Course Credit – 4

Course Title – Organic Chemistry - IV

Module-1: Carbocycles and Heterocycles:

Unit-1: Polynuclear hydrocarbons and their derivatives:

Classification, Properties, Sources of Polynuclear Hydrocarbons, Properties, Synthetic methods of naphthalene, anthracene, phenanthrene including Haworth, Bardhan-Sengupta, Bogert-Cook and other useful syntheses; fixation of double bonds and Fries rule; reactions and uses of naphthalene, anthracene, phenanthrene.

Unit-2: Heterocyclic compounds:

Heterocycles with fused five-membered ring, Fused six – membered heterocycle; reactivity, orientation and important reactions of furan, pyrrole, thiophene and pyridine; Synthesis of furan: Paal-Knorr synthesis, Feist- Benary synthesis and its variation; Synthesis of pyrrole: Knorr synthesis; Synthesis of thiophenes: Hinsberg synthesis; Synthesis of pyridine: Hantzsch synthesis; Synthesis of of pyridines; Synthesis of indole: Fischer – indole synthesis, Madelung synthesis and Bischler synthesis; Synthesis of quinoline: Skraup synthesis, Friedlander synthesis Knorr quinoline synthesis Doebner- Miller, Combes synthesis; Synthesis of isoquinoline: Bischler-Napieralski synthesis, Pictat – Spengler synthesis,

Module-2: Cyclic Stereochemistry

Unit-3: Cyclic Stereochemistry

Introduction, Alicyclic Hydrocarbons and Strain Energy, Bonding in cycloalkanes-angle strain and torsional strain, Consequences of angle strain for cyclic compounds, Baeyer's strain theory, Conformations of Cyclohexane, Conformations of Cyclohexanes with One Substituent, Conformations of Cyclohexanes with Two Substituent

Module-3: Pericyclic Reactions:

Unit-4: Pericyclic Reactions:

Introduction, Electronic Excitation, Symmetry in π molecular orbital, Frontier Molecular Orbital (FMO), Mechanism, stereochemistry, regioselectivity in case of Electrocyclic reactions: FMO approach, HOMOs of Polyenes, Electrocyclic ring closing reactions for (4n+2) π electron system (thermal and photochemical), Electrocyclic ring opening reactions for (4n+2) π electron system

(thermal and photochemical), Cycloaddition reactions: FMO approach, [2+2] Cycloaddition, [4+2] Cycloadditions (Diels-Alder reaction), Cycloreversion or Retro cycloaddition Reactions, Sigmatropic reactions: FMO approach, sigmatropic shifts and their order; [1,3]- and [1,5]- H shifts, [1,5]- shifts and [3,3]-shifts with reference to Claisen and Cope rearrangements.

Module-4: Biomolecules:

Unit-5: Amino acids:

Amino acids, Classification, Synthesis of α-Amino Acids: Strecker Synthesis, Gabriel Synthesis, Resolution of amino acids, Reactions of α-Amino Acids: Carboxylic Acid Esterification, Amine Acylation, Ninhydrin Reaction, Oxidative Coupling, Dakin-West reaction, The Isoelectric Point, zwitterions, Electrophoresis

Unit-6: Peptides:

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

Unit-7: Nucleic acids:

Nucleic acids, pyrimidine and purine bases (only structure & nomenclature); nucleosides and nucleotides corresponding to DNA and RNA; mechanism for acid catalyzed hydrolysis of nucleosides; comparison of alkaline hydrolysis of DNA and RNA; elementary idea of double helical structure of DNA (Watson-Crick model); complimentary base–pairing in DNA.

Module-5: Green Chemistry:

Unit-8: Introduction to Green Chemistry:

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry, Twelve principles of Green Chemistry with their explanations, examples.

Unit-9: Designing a Green synthesis:

Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy.

Unit-10: Designing Safer Chemicals:

Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization-careful use of blocking/protecting groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, symmetric catalysis and photocatalysis.

Unit-11: Examples of Green Synthesis and Rearrangement:

Green Synthesis of the adipic acid, Rearrangement reactions by green approach: Fries rearrangement, Claisen rearrangement, Beckmann rearrangement, Baeyer-Villiger oxidation.

Unit-12: Green Reactions of carbonyl compounds:

Need of Green Chemistry, Principles of green chemistry; Common green reactions of carbonyl compounds: Aldol, Friedel-Crafts, Michael, Cannizzaro, benzoin condensation

Unit-13: Microwave and Ultrasound assisted reactions:

Microwave Irradiated Pericyclic Reaction, Nucleophilic Substitutions under Microwave Irradiation, Alkylation Reactions under Microwave Irradiation. Microwave Irradiated Radical Reactions, Ultrasound Applications in Bioethanol and Biodiesel Production

Unit-14: Future Trends in Green Chemistry:

Cradle to Cradle Carpeting, Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Cocrystal Controlled Solid-State Synthesis (C3S3); Green chemistry in sustainable development.

Course Code – 8CC-CH- 20 Course Credit – 4

Course Title – Physical Chemistry - IV

Module 1: Solid State of Matter

Unit 1: The Solid State - I

Types of solid; Lattice, space lattice, unit cell, crystal planes, Bravais lattice; Laws of crystallography; Elementary ideas of symmetry, symmetry elements and symmetry operations; Qualitative idea of point and space groups; Packing of uniform hard sphere, Close packed arrangements (fcc and hcp); Tetrahedral and octahedral voids. Void space in cubic systems

Unit 2: The Solid State - II

Distance between consecutive planes [cubic and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of d_{hkl}; Relation between molar mass and unit cell dimension for cubic system; X-ray diffraction and Bragg's law (derivation)Determination of crystal structure: Powder method; Structure of NaCl and KCl crystals; 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

Module 2: Quantum Chemistry - II

Unit 3: Angular momentum

Commutation rules, quantization of square of total angular momentum and z-component; Rigid rotator model of rotation of diatomic molecule; Schrödinger equation, transformation to spherical polar coordinates; Separation of variables. Spherical harmonics; Discussion of solution

Unit 4: 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

Unit 5: Many Electronic Atoms

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).

Unit 6: LCAO Method

Born-Oppenheimer approximation. Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+; Bonding and anti bonding orbitals; Qualitative extension to H_2; Comparison of LCAO-MO and VB treatments of H_2 and their limitations (only wavefunctions, detailed solution not required) and their limitations

Module 3: Molecular Spectroscopy and Photochemistry

Unit 7: Electromagnetic radiation and Rotational Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

Rotation spectroscopy: selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, effect of isotopic substitution on rotational spectroscopy, rotational spectra for non-rigid molecular systems.

Unit 8: 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, R branches

Unit 9: Raman Spectroscopy

Classical Treatment. Rotational Raman effect; Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion

Unit 10: 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;

Unit 11: NMR and ESR Spectroscopy

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales (δ and T), spin-spin coupling and high resolution spectra, interpretation of PMR spectra of simple organic molecules like methanol, ethanol, acetaldehyde, acetic acid and aromatic proton; Electron Spin Resonance (ESR) spectroscopy: Its principle, ESR of simple radicals

Unit 12: Photochemistry – Laws of Photochemistry

Lambert-Beer's law and its limitations, physical significance of absorption coefficients; Photochemical reactions Laws of photochemistry, Stark-Einstein law of photochemical equivalence; quantum yield, actinometry, examples of low and high quantum yields

Unit 13: Photochemistry – Rate of Photochemical processes

Photochemical equilibrium and the differential rate of photochemical reactions, Photostationary state; HI decomposition, H_2-Br_2 reaction, dimerisation of anthracene; photosensitised reactions, quenching; Role of photochemical reactions in biochemical processes, chemiluminescence

Module 4: Surface Phenomenon

Unit 14: 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)

Unit 15: 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

Course Code – 8CC-CH- 21 Course Credit – 4

Course Title – Advanced Inorganic Chemistry

Module I: Supramolecular Chemistry, Advance Materials, Perovskite & Solid-State Chemistry

Unit 1: Supramolecular Chemistry

Introduction: Complementarity in biology, lock (host) and key (guest) principle. Non-covalent interaction in supramolecular systems. Design principle: chelate and macrocyclic effects, Cation binding: Introduction, synthesis of macrocyclic receptors for cations, techniques used for synthesis of macrocyclic-crown ethers, cryptands, spherands and siderophores.

Unit 2: Advance Materials

Preparation, characterization, theoretical understanding, properties & applications; quantum dots; nano-composites; organic semiconductors, fullerenes, carbon nanotubes, graphene.

Unit 3: Solid state chemistry

Defects in solids, line and plane defects. Determination of equilibrium concentration of Schottky and Frenkel defects, Stoichiometric imbalance in crystals and non-stoichiometric phases, Color centres in ionic crystals. Band theory, band gap, metals, insulators, semiconductors (intrinsic and extrinsic)

Unit 4: Perovskite Materials

Introduction, Synthesis, Characteristics, Types of perovskites, properties, Examples

Module II: Bioinorganic Chemistry, Crystallography & Inorganic Reaction Mechanism

Unit–5: Bioinorganic Chemistry-I
Bioenergetic principle and role of ATP. Metal ion transport and storage proteins: ferritin, transferrin, ceruloplasmin. Electron transport proteins: cytochromes, cytochrome P-450 enzyme, peroxidases, Catalases, Fe-S proteins, Cobalamins including vitamin and coenzyme B12.

Unit–6: Bioinorganic Chemistry-II
Hemoglobin, myoglobin, Hemerythrin and Haemocyanin. Photosynthesis, Chlorophyll, PS-I, PS-II, photosynthetic electron transport chain. Metalloporphyrin, nitrogen fixation, cytochrome c oxidase, metals in medicine

Unit–7: Primary concept on Crystallography

Crystal and lattice, process of crystallizations, crystal form, habit, defect, lattice planes, indices, crystal systems and symmetry, primitive and non-primitive lattice, diffraction of X-ray, Brag's condition, reciprocal lattice, Brag's law in reciprocal lattice, Ewald sphere, X-ray Crystallography Instrumentation

Unit–8: Inorganic Reaction Mechanism

Introduction, Different types of reactions, Four broad classes of mechanism of substitution---"D", "A", "Ia" and "Id"; Mechanism of substation reactions in square planar, tetrahedral and octahedral geometries with special reference to d^n ion complexes; Mechanism of isomerization reaction----linkage isomerism, cis-trans isomerisms, recimization; trans and cis effect and trans influence; Mechanism of electron transfer reactions: outer sphere and Inner sphere reactions.

Module III: Electrochemical Analysis, EPR & Mössbauer Spectroscopy

Unit–9: Electrochemical Analysis

Voltammetry: cyclic voltammetry, linear sweep voltammetry; Amperometry; Coulometry; Electrogravimetry

Unit–10: EPR Spectroscopy

Principle of EPR and comparison to NMR spectroscopy, spectrometer, external standard, line-width, nuclear hyperfine interactions, anisotropy in Lande g factor and hyperfine interaction, structural information of organic radicals and inorganic molecules (only one unpair electron systems) from EPR spectra.

Unit 11: Mössbauer Spectroscopy

Primary concept on Mössbauer spectroscopy, principle, experiment, line-width, center shift, quadrupole interaction, magnetic interaction; information of spin and oxidation states, structure and bonding, spin transition from spectra of Mössbauer active nuclei (iron) in variety of environments.

Module IV: Nanomaterials, Organometallic Catalysis & Reactions in Organometallic Chemistry

Unit–12: Nanomaterial

Introduction to nanoworld, Fundamental theories of nanoparticles (NPs), 0D, 1D and 2D nanoparticles and their physical, optical, electronic, magnetic properties, Methods of fabrication of metal organic and composite NPs, Application of NPs, nanoelectronics and devices.

Unit 13: Catalysis by Organometallic Compounds

Definition and importance of catalyst with special emphasis on organometallic catalysts. Use of organometallic catalysts with reference to industrially important processes, examples of green fuels, biodiesel, H_2-fuel, Hydrogen evolution reactions.

Unit–14: Reactions in Organometallic Chemistry

Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertion reactions.

Course Code – 8CC-CH- 22 Course Credit – 4

Course Title – Advanced Organic Chemistry

Unit–1: Structure-Activity Relationship

MO treatment of acyclic and cyclic conjugated systems; Frost diagram, Huckel treatment – applications to ethylene, allyl, butadiene, cyclobutadiene systems, Hammett equation and its modifications.

Unit–2: Aromaticity:

Huckel's rule and concept of aromaticity, annulenes, heteroannulenes, fullerenes (C60), anti-aromaticity, pseudo-aromaticity, homo-aromaticity; graphical methods.

Unit–3: Advanced Stereochemistry

Conformational analysis of cyclohexene and decalin; perhydro anthracene, etc. Stereochemistry of nucleophilic addition reactions to carbonyl compounds: Felkin-Anh, Cieplak and Zimmerman-Traxler Models. Curtin-Hammett principle. Stereochemistry behind oxidation of cyclohexanol and esterification, saponification, lactonisation, epoxidation, pyrolytic syn elimination and fragmentation reactions

Unit–4: Pericyclic Reactions

Introduction to pericyclic reactions, Thermal and photochemical pericyclic reactions: electrocyclic reactions, cycloaddition reactions and sigmatropic rearrangements. Rationalization based on Frontier M.O. approach, correlation diagrams. The Woodward-Hoffmann selection rules. General perturbation molecular orbital theory in cycloaddition reactions; Cope and Claisen rearrangements, Ene reaction.

Unit–5: NMR Spectroscopy

Principle, instrumentation and different techniques of NMR spectroscopy. Introduction to ^{13}C NMR spectroscopy, application of NMR spectroscopy and other spectroscopical techniques to simple structural and mechanistic problems. Rules for carbon13 calculations.

Unit–6: Mass Spectroscopy

Basic Principles, instrumentation and applications of mass spectrometry. Detection of ions, ion analysis, ion abundance, molecular ion peak, metastable peak, isotopes, ion-molecule interaction and analysis of fragmentation patterns. Applications of mass spectroscopy to simple structural and mechanistic problems.

Unit–7: Photochemistry-I

Basic principles, Jablonski diagram, photochemistry of olefinic compounds, Cis-trans isomerisation

Unit–8: Photochemistry-II

Paterno-Buchi reaction, Norrish type I and II reactions, photo reduction of ketones, di-pi-methane rearrangement, photochemistry of arenes,

Unit–9: Organoboron compounds

Preparation and Chemistry of organo boron compounds, carboranes, hydroboration, reactions of organoboranes, unsaturated hydrocarbon synthesis, allylboranes, boron enolates.

Unit–10: Organophosphorus compounds

Chemistry of organophosphorus compounds, Phosphorus ylides and chiral phosphines.

Unit–11: Organosilicon compounds

Chemistry of organosilicon compounds, Synthetic uses of silyl ethers, silylenol ethers, TMSCN, alkene synthesis, silicon Baeyer Villiger rearrangement

Unit–12: Heterocyclic Chemistry

Nomenclature of simple heterocyclic compounds, Synthesis and reactivity of pyridine, quinoline, isoquinoline, indole, pyrazole, oxazole, thiazole, and their applications in organic synthesis.

Unit–13: Chemistry of natural products:

Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.

Unit–14: Organic supramolecular chemistry:

Basic concept and principles; History, Molecular recognition, Hydrogen Bonds: Simple example and use in organic chemistry.

Course Code – 8CC-CH- 23 Course Credit – 4

Course Title – Advanced Physical Chemistry

Module 1: Mathematics for Chemistry

Unit 1: Functions and Transformations I

Functions, limits, derivative, physical significance, basic rules of differentiation, maxima and minima, Error function, Gamma function, exact and inexact differential; applications in chemistry

Unit 2: Functions and Transformations II

Taylor and McLaurin series, Fourier series and Fourier Transform, Laplace transform, partial differentiation,

Unit 3: Integrals

rules of integration, definite and indefinite integrals, Integration by parts with examples

Unit 4: Differential Equations

Separation of variables, homogeneous, exact, linear equations, equations of second order, series solution method.

Unit 5: Probability

Permutations, combinations, and theory of probability with examples

Unit 6: Vectors and matrices

Vectors, dot, cross and triple products, introduction to matrix algebra, addition and multiplication of matrices, inverse, adjoint and transpose of matrices, unit and diagonal matrices

Unit 7: Numerical Analysis I

Roots of Equation: Numerical methods for finding the roots of equations: Quadratic Formula, Iterative Methods (e.g., Newton Raphson Method). Least-Squares Fitting.

Unit 8: Numerical Analysis II

Numerical Differentiation. Numerical Integration (Trapezoidal and Simpson's Rule)

Unit 9: Qualitative and quantitative aspects of analysis I

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors,

Unit 10: Qualitative and quantitative aspects of analysis II

Statistical test of data; F, Q and t test, rejection of data, and confidence intervals

Unit 11: Qualitative and quantitative aspects of analysis III

Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit. Basic aspects of multiple linear regression analysis.

Module 2: Statistical Thermodynamics

Unit 12: Statistical Thermodynamics - I

Configuration: Macrostates, microstates and configuration; calculation with harmonic oscillator; variation of W with E; equilibrium configuration

Unit 13: Statistical Thermodynamics - II

Partition function, concept of ensemble - canonical ensemble and grand canonical ensembles, Partition function: molecular partition function and thermodynamic properties, Stirling Approximation; Absolute entropy, Plank's law, Calculation of entropy,

Unit 14: Statistical Thermodynamics - III

Boltzmann distribution: Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution;

Course Code – NEC-CH- 1 Course Credit – 4

Course Title – Application Oriented Chemistry-1

Unit-1. Chemical Analysis: Principle and Application

Principles of acid-base, oxidation-reduction (Permanganometry, Dichromatometry) and complexometric titrations, Hardness of water,

Unit-2: Chromatography:

Principles of chromatographic separation, GLC, TLC, GC and HPLC, Elementary idea of Solvent extraction.

Unit-3. Polymer Chemistry:

Preliminary ideas of polymers, different schemes of classification of polymers, polythene, PVC, polyurethane, biopolymers, composition and uses of polymers.

Unit-4. Fuels:

(i) Gaseous Fuel: Manufacture & uses of producer gas, water gas, light petroleum gas and bio-gas.

(ii) Liquid fuels: Crude oil-gasoline, diesel oil, octane number, cetane number, antiknock compounds

Unit-5. Paints, Varnishes

Primary constitution of paints, binders and solvents for paints, oil based paints, latex paints, Composition of varnishes, formulation of paints and varnishes

Unit 6: Synthetic Dyes:

Synthesis of methyl orange, Congo red, malachite green, crystal violet and applications

Unit-7. Drug and Pharmaceuticals

Introduction about drug and pharmaceuticals, preparation and extraction, purification and uses of aspirin, paracetamol, enovid, sulphadiazine, chloroquine, metronidazole, vitamins-B_{12}& B_6, penicillin

Unit-8. Domestic and useful materials

Fats and oils, edible and inedible oil, glycerides, enzyme based detergents, detergents powders, liquid soaps, Cosmetics and perfumes, application and side effects of hair dyes, hair sprays, creams, lipstic, face powder, talcom powder, tooth paste, nailm polish, shampoos, jasmone, amylacetate

Unit-9. Pesticides Insecticides

Classification of Pesticides, Common pesticides: Production, application and toxicity of gammaxene, aldrin, parathion, malathion, DDT, paraquat, organophosphorus, carbamates,

Unit-10: Food Additives

Food flavour, food colour, food preservatives, artificial sweeteners, MSG its applications and side effects, edible emulsifiers and edible foaming agents.

Unit-11: Cement and electroplating

Composition of cement, manufacture and uses, setting of cement, determination of quality of cement, Theories of electroplating, galvanization application and uses

Unit-12. The atmosphere

Structure of atmosphere, Ozone layer and its role, major air pollutants, CO, SO_2, NO_x, SPM, ozone layer depletion, greenhouse effect, acid rain, smoke, sulphurous smoke, air pollution effect and methods of prevention

Unit-13. The hydrosphere I

Water pollutants: action of soaps, detergents, phosphates, arsenic, industrial effluents, agriculture runoff, radioactive pollution and effects on animal and plants.

Water pollution control measures, waste water treatments, chemical treatments and microbial treatment,

Unit 14: The hydrosphere II

Water quality parameters, DO, BOD, COD, and TDS. Desalination of sea water and reverse osmosis

Course Code – NEC-CH- 2 Course Credit – 4

Course Title – Basic Physical Chemistry

Unit-1: Chemical Thermodynamics -I

Brief review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.

Unit-2: Chemical Thermodynamics -II

Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit-3: Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^{o}, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

Unit-4: Ionic Equilibria I

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.

Unit 5: Ionic Equilibria II

Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Unit-6: Kinetic Theory of Gases I

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation).

Unit-7: Kinetic Theory of Gases II

Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Unit-8: Real Gases

Deviation of real gases from ideal behavior, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants.

Unit-9: Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

Unit-10: Solids -I

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices.

Unit-11: Solids -II

Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals.

Unit-12: Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature- composition curves of ideal and non-ideal solutions. Partial miscibility of liquids: Critical solution temperature; Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Unit-13: Chemical Kinetics - I

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction.

Unit-14: Chemical Kinetics - II

Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Course Code – NEC-CH- 3 Course Credit – 4

Course Title – Basic Inorganic Chemistry

Unit-1: Theories of Atomic Structure:

Review of: Bohr's theory and its limitations, dual behavior of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Unit 2: Electronic Configuration of Atoms

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit-3: Ionic Bonding:

General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Unit 4: Covalent bonding:

VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

Unit 5: Molecular Orbital Theory

MO Approach, Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

Unit-6: s-and p-Block Elements:

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales). Allotropy in C, S, and P.
Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Unit-7: Compounds of s- and p-Block Elements:

Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of p- block elements.

Unit 8: Elements of Bio-inorganic Chemistry

Sodium, potassium, calcium, magnesium, iron, cobalt, nickel

Properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Unit 9: Hydrides of Boron

B_2H_6, B_4H_{10}, B_5H_9, B_5H_{11}

Unit 10: Compounds of P, S and Cl

Oxoacids of P, S and Cl, Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2

Unit-11: Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states for Mn, Fe and Cu.

Unit 12: Basics of coordination chemistry

Werner's theory, EAN rule, classification of ligands and their binding modes, IUPAC nomenclature of coordination compounds (up to two metal centers), overall and stepwise stability constants, chelates, innermetallic complexes

Unit-13: Coordination Compounds and Isomerism

Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Isomerism, Structural and stereoisomerism in complexes with coordination numbers 4 and 6

Unit-14: Radioactivity

Atomic nucleus; artificial radioactivity, nuclear stability, n/p ratio and different modes of decay, Nuclear reactions, Fusion, Fission, Spallation reaction, mass defect, packing fraction and nuclear binding energy, magic numbers.

Course Code – NEC-CH- 4 Course Credit – 4

Course Title – Basic Organic Chemistry

Unit-1: Fundamentals of Organic Chemistry:

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

Unit-2: Stereochemistry:

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis* - *trans* nomenclature;

CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E/Z Nomenclature (for upto two C=C systems).

[N.B: For Alkanes, Alkenes & Alkynes functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure]

Unit-3: Alkanes:

(Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Unit-4: Alkenes:

(Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Unit-5: Alkynes:

(Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. *Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$. (Case benzene): Electrophilic substitution: nitration, halogenation and sulfonation. Friedel-Craft's reaction (alkylation and acylation

Unit-6: Aromatic hydrocarbons:

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Unit-7: Alkyl and Aryl Halides:

Alkyl Halides (Upto 5 Carbons) *Preparation:* from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation. Williamson's ether synthesis

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit-8: Alcohols:

Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* oxidation of diols. Pinacol-Pinacolone rearrangement.

Unit-9: Phenols:

(Phenol case) *Preparation:* Cumenehydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer- Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction.

Unit-10:

Ethers (aliphatic and aromatic): *Preparation & Reactions:* Cleavage of ethers with HI.

Unit-11: Carbonyl compounds

(Aldehydes and ketones): (Formaldehyde, acetaldehyde, acetone and benzaldehyde) *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

Unit-12: Carboxylic acid derivatives (aliphatic and aromatic):

Preparation: Acidic and Alkaline hydrolysis of esters, Acid chlorides, Anhydrides, Esters. Amide derivative from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Hell – Vohlard – Zelinsky Reaction, Reformatsky Reaction, Perkin condensation.

Unit-13: Amines and Diazonium Salts:

Amines (Aliphatic and Aromatic): (Upto 5 carbons) *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: *Preparation:* from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

Unit-14: Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, maltose, lactose) and polysacharride (starch) excluding their structure elucidation.

Course Code – NSE-CH-01 Course Credit –4

Course Title – Pharmaceutical Chemistry

Unit-1: Drug discovery, design and development; Basic Retrosynthetic approach.

Unit-2: Preparation of Aspirin and magnesium bisilicate (Antacid).

Unit-3: Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti- inflammatory agents (Aspirin, paracetamol, lbuprofen);

Unit-4: antibiotics (Chloramphenicol);

Unit-5: antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir),

fermentation. Production of the following compounds by fermentation (i) Ethyl alcohol and citric acid, (iii) Lysine, Glutamic acid, Vitamin B_2, Vitamin B_{12} and Vitamin C

Unit-6: Central Nervous System agents (Phenobarbital, Diazepam),

Unit-7: Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone),

Unit-8: HIV-AIDS related drugs (AZT- Zidovudine).

Unit-9: Aerobic and anaerobic

Unit-10: Production of the following Antibiotics by fermentation process; Penicillin, Cephalosporin, Chloromycetin and Streptomycin

Course Code – NSE-CH-02 **Course Credit – 4**

Course Title – Analytical clinical biochemistry

Unit 1: Basics of Carbohydrates

Definition (both classical and modern), Classification in details, Oxidation and reduction of D-(+)-Glucose and D-(-)Fructose, Primary functions of Carbohydrates, Biological importance of Carbohydrates, Howarth structure of α and β D-Glucose, Fructose, Starch, Sucrose, Lactose, Maltose, Alcoholic and lactic acid Fermentation..

Unit 2: Carbohydrate Metabolism

Catabolism, Anabolism, Sequence of Glycolysis, Products of Glycolysis, Importance of Glycolysis, Fate of Pyruvate, Steps and reaction sequence of Krebs cycle, Features of Krebs Cycle, Significance of Krebs Cycle, Difference between Glycolysis and Krebs Cycle, Total ATP formation calculation in both processes.

Unit 3: Basics of Proteins

About Amino Acids and its classification, Isoelectric Point, Detail classification of Proteins, Biological Importance of Protein, Four levels of Protein Structure, Denaturation of Proteins., Renaturation.

Unit 4: Isolation and Characterization of Carbohydrates and Proteins

Qualitative Detection of Carbohydrates: Molisch Test, Benedict's test, Barfoed's test, Iodine test (for polysaccharides)

Qualitative Detection of Proteins: Ninhydrin test for amino acid, Ion exchange Chromatography, Electrophoresis, Biuret reaction, Lead acetate test (for sulphur containing amino acids)

Unit 5: Basics of Enzymes

Properties, IUBMB Nomenclature, Co-factor, Apoenzyme, Holoenzyme, Coenzymes, Specificity of Enzyme, Reversible Inhibitor, Irreversible Inhibitor, Biological importance of Enzyme, Role of Enzyme in Green Chemistry, Biocatalyst, Ribozymes.

Unit 6: Mechanism and Kinetics of Enzyme

Energy profile of reactions catalysed by Enzymes, Types of Catalytic Mechanism, Various Models for Enzyme Action, The Michale-Menten Equation, Analysis of Kinetic data, factors influencing Enzyme Activity.

Unit 7: Lipids

Classification, Importance of Triglycerides, Phosphoglycerides and Cholesterol, Lipid membrane, Liposome and their biological function, Lipid bilayer formation, biological role of Lipids, Structure and Function of Fatty Acid.

Unit 8: Lipoproteins and Hormones

Classification and Biological Role of Lipoproteins, Properties and Biochemical Functions of Steroid hormones, Biochemistry of Peptide hormones.

Unit 9: Nucleic Acids; DNA and RNA

Chemical Structure of DNA, Chemical Structure of RNA, Biological Roles of DNA & RNA, Differences between DNA & RNA, DNA Replication, Protein Synthesis from DNA via RNA, Transcription, Genetic Code.

Unit 10: Basics of Blood

Physical properties and Composition of Blood, Function of each Blood Corpuscles, Blood Coagulation, Importance of Blood, Anaemia and its Classification.

Unit 11: Blood Analysis

Blood Collection, Preservation of Blood Sample, Estimation and Interpretation of data for Blood Sugar, Urea, Creatinine, Cholesterol and Bilirubin.

Unit 12: Urine Analysis

Urine Collection, Urine preservation, Physical examination of Urine, Normal Chemical Composition of Urine, Abnormal composition of Urine, Test to estimate Glucose in Urine, Test to estimate Protein in Urine, Test to estimate Ketone bodies in Urine.

Course Code – NSE-CH-03 Course Credit – 4

Course Title – Fundamental Environmental Chemistry

Module –I Environment and Ecosystem

Unit-1: The Concepts of Environmental Chemistry

Scope of Environmental Chemistry; Cosmic origin of elements; Origin of Life on Earth and Biogeochemical Evolution; Evolution in the Prebiotic Environment; Elements of Life and Biodistribution; Environment – definition, component and segments, Ecology; Ecosystems; Energy Flow in an Ecosystem; Ecological Pyramids; Anthropogenic Impact on Natural Ecosystems

Unit-2: Chemistry of the Atmosphere

Evolution of Atmosphere; Chemical Composition of the Atmosphere; Physical and Chemical Properties of Atmospheric Gases; Protective Role of the Atmosphere; Aerosols; Suspended Particulate Matter; Atmospheric Stratification, Temperature-Pressure Variations, and Climate Influence.; Heat Budget of the Earth; Chemical and Photochemical Reactions in the Atmosphere; Chemistry of the Hydroxyl, Hydroperoxyl and Nitrate Radicals

Unit-3: Chemistry of the Hydrosphere

Properties of water; Hydrosphere: components, composition and properties, importance; The Hydrological Cycle; Oceans: origin, primitive ocean, chemical composition of sea water; Aqueous Chemistry of Carbon Dioxide (CO_2), Oxygen, Metal Ions; Chemistry of Humic Substance and Complexing Agents in Natural Water Bodies; Geochemical Balance of the

Dissolved Materials; Marine Ecology; El Nino and La Nina; Chemistry of Estuarine Water and River Water; Chemistry of the Ground Water and Rain Water; Cryosphere Chemistry and Polar Water Chemistry; Measurement of Water Quality Parameters (pH, DO, BOD, COD, TDS, Hardness, etc.)

Unit-4: Chemistry of Soil

Geosphere: Formation, structure, composition; Terrestrial Abundance and geochemical classification of Elements; Soil: Formation, rock and rock cycle, composition, classification; Clay; Chemical properties of soil; Macronutrients and Micronutrients in Soil; Fertilizers and Manures; Soil Organic Matter and Decomposition Chemistry; Waste and pollutants of soil, Soil Erosion

Unit-5: Chemistry of Biosphere

Biosphere; Natural Cycles; The Carbon Cycle, The Oxygen Cycle, The Nitrogen Cycle; The Phosphorus Cycle; The Sulfur Cycle; Impact of Human Activities on Biogeochemical Cycles;

Module –II: Pollution Chemistry

Unit-6: Air Pollution - I

Air Pollutants: General Aspects, common air pollutants and their threshold values, toxicities of air pollutants, standard air quality parameters; Air Quality Index (AQI) and Monitoring Techniques, Atmospheric Stability, Temperature Inversion, and Air Quality

Chemistry of Ozone Layer: Role of Ozone Layer; Ozone Cycle, Formation of Ozone Holes, Ozone Depleting Substances and Ozone Depletion Potentials (ODPs), Effects of Ozone Depletion and remedy;

Greenhouse Effect — greenhouse gases and their interaction with the IR radiation, global warming potentials (GWPs) of greenhouse gases, consequences of greenhouse effect, control and moderation of greenhouse effect;

Particulate Matter (PM): introduction, size and classification, sources, Inorganic and organic fate of particulates, adverse effects, control.

Unit-7: Air Pollution - II

Smog Formation in Air; Photochemical Smog, its effect; Chemistry of photochemical smog formation, catalytic converters, control of photochemical smog; Sulfurous Smog: formation, control of its formation, adverse effects, Carbon Monoxide in Air: production, fate, toxicity, and control;

Carbon dioxide in Air: production, fate, toxicity, and control; Oxides of nitrogen in Air: production, fate, toxicity and control; Oxides of sulfur in Air: production, fate, toxicity and control; Acid rain; Ammonia, halogens, sulfides in air; Hydrocarbons and Volatile Organic Compounds in air; Perfluorocarbons in Atmosphere; Atmospheric Turbidity and Nuclear Winter; Catastrophic Dioxygen Depletion; Radioactive Pollution in Atmosphere; Vehicular Emissions and Alternative Fuels; Octane Rating, Antiknock Agents, and Lead-Free Fuels.

Unit-8: Water Pollution

Ground, Surface and Marine Water Pollution, Sources of Water Pollution; Water Pollutants; Acid Mine Drainage (AMD) Chemistry and Remediation Methods; Eutrophication: causes, effects and control; Marine pollution and Oil Pollution; Historical Water Pollution Disasters; Self-Purification of Water; Hardness of water; Control of water pollution and Waste water treatment; Advanced Purification Techniques: Reverse Osmosis, UV Disinfection, Activated Carbon Filtration; Emerging Water Contaminants: Pharmaceuticals, Microplastics, and Personal Care Products; Desalination of Sea Water; Microplastics and Nanoparticles in Air and Water

Unit-9: Industrial Pollution

Concept and examples; Air Pollutants from Industries; Industrial Wastes, Types of industrial Wastes in Effluents; Water Pollutants from Industrial Effluents; Treatment and Disposal of Industrial Waste; Bioremediation, Phytoremediation, and Biofilters; Zero-Liquid Discharge (ZLD) Technologies for Industrial Effluents.

Unit-10: Agricultural Pollution

Pesticides and Insecticides — Characteristics, mode of action and Classification; Structural Features of Some Common Insecticides- DDT, BHC, polychlorinated cyclopentadiene derivatives, organophosphates, sevin etc.; Fungicides: Characteristics, features and examples; Herbicides: Characteristics, features and examples; Organic Farming, Integrated Pest Management (IPM), and Biopesticides; Fertilisers and Environmental Hazards

Unit-11: Environmental Toxicology

Concept of environmental toxicology; Toxic Substances and their effect; Carcinogens, Teratogens and Mutagens; Metal ion toxicity; Anion toxicity; Hazardous Organometallic Compounds; Toxic effect of common chemicals;

Unit 12: Radioactive Pollution

Health and Environmental Impact of Ionizing Radiation; Natural Background Radiation; Radiation from Human Activity; Units of measurement of radiation; Radioactive Fallout and Nuclear Winter; Nuclear Waste; Nuclear Catastrophes Case Studies: Chernobyl, Fukushima, Three Mile Island

Course Code – NMD-CH- 1 Course Credit – 4

Course Title – Chemistry in Daily Life

Module-1:

Unit-1: Food Chemistry:

Components of food: Water, Carbohydrate, protein, fat, vitamin, minerals, natural colours of food: Carotenoids, Chlorophyll, Hemoglobin, cytochrome, flavonoids, artificial food colours, Gene modified food, toxic elements in food, preservation of food, antioxidant

Unit-2: Nutritional Science:

Different types of food items: Carbohydrate rich food, legume, fish-egg-meat, Fruits and vegetables, milk, balanced diet, analysis of food, food value, Recommended Dietary Allowance, Malnutrition,

Unit-3: Toxicology in Food item

Types of toxicity in food, Goitrogens, allergen, lectin, antienzyme, antivitamins, antimetabolite, lathyrogens, carcinogen, food management, rancidity, acidity, xenobiotic toxic, toxicity in food,

Unit-4: Fermentation

Definition, role of microorganism in food chemistry, industrially fermented food, fermentation in chemical preparation, role of yeast, mold and actinomyces

Unit-5: Food technology

Preservation of food, processed fruit items: Jelly, Jam, Marmaled, sqash, pickle, sauce, technology in food grains, bakery industry,

Module-2:

Unit-6: Water Pollution

Source, classification and happening of water pollution, demerits of water pollution, remedies to control of water pollution, different processes for removing water pollution, B.O.D, C.O.D. & D.O,

Unit-7: Air Pollution

Source, classification and happening of air pollution, demerits of air pollution, remedies to control of air pollution, remedies for removing air pollution, greenhouse effect, ozone layer depletion, acid rain, smog

Unit-8: Fuel

Types of fuel, calorific value, solid fuel coal, liquid fuels, gaseous fuel, alternative source of fuel, solar energy

Unit-9: Soap and Detergent

Types of soap, preparation of soap, properties of soap, liquid soap, cleaning action of soap, detergent, cleaning action of soap, difference between soap and detergent, hard water, various types of treatment for removing hardness of water, hardness of water

Unit-10: Cosmetics and Dyes

Types of cosmetics, components and use of talcum powder, cream, hair dyes, hair spray, lipsticks