WEST BENGAL STATE UNIVERSITY

SYLLABUS in CHEMISTRY

Under

Curriculum and Credit Framework for Undergraduate Programmes

Part A: Syllabus of Major (Core Course) for 4-year HONOURS in CHEMISTRY

Part B: Syllabus of Minor Course in Chemistry for 4-year UG Programme (Honours in subjects other than Chemistry) and 3-year Multidisciplinary UG Programme.

Part C: Skill Enhancement Course in Chemistry

Part D: Multidisciplinary Course (MDC) in Chemistry

Part A

Major (Core Course) for HONOURS in CHEMISTRY

SEMESTER I

Paper	Course ID	Course Content	Marks	Total Credit
FUNDAMENTALS OF CHEMISTRY 1	**CEMDSC101T**	Unit-1: Atomic Structure and chemical periodicity Unit-2: Basics of Organic chemistry Unit-3: Kinetic Theory and Gaseous State	Theoretical : 50	03
	CEMDSC101P		Practical : 50	02

SEMESTER II

Paper	Course ID	Course Content	Marks	Total Credit
FUNDAMENTALS OF CHEMISTRY 2	**CEMDSC202T**	Unit-1:Acid-Base reactions Unit-2: Stereochemistry Unit-3: Chemical Kinetics	Theoretical : 50	03
	CEMDSC202P		Practical : 50	02

SEMESTER III

Paper	Course ID	Course Content	Marks	Total Credit
CHEMICAL REACTION : PROPERTIES AND ENERGETICS	**CEMDSC303T**	Unit-1: Chemical Periodicity 2 and Redox reactions Unit-2:Substitution, Elimination Reactions and Reaction Kinetics Unit-3: Chemical Thermodynamics-I	Theoretical: 50	03
	CEMDSC303P		Practical: 50	02

SEMESTER IV

Paper	Course ID	Course Content	Marks	Total Credit
INORGANIC CHEMISTRY 1	**CEMDSC404T**	Unit-1: Radioactivity Unit-2: Chemical Bonding-I Unit-3: Chemical Bonding-II Unit-4: Chemical Bonding-III	Theoretical: 50	03
	CEMDSC404P		Practical: 50	02
ORGANIC CHEMISTRY 1	**CEMDSC405T**	Unit-1: Stereochemistry II Unit-2: Chemistry of Alkanes, Alkenes and Alkynes Unit-3: Aromatic Substitution Reactions and Phenols Unit-4: Alcohols, Ethers, Carboxylic acids and their derivatives	Theoretical: 50	03
	CEMDSC405P		Practical: 50	02
PHYSICAL CHEMISTRY 1	**CEMDSC406T**	Unit-1: Chemical Thermodynamic-II Unit-2 : Chemical and ionic equilibrium Unit-3 : Transport Phenomenon Unit-4: Quantum Mechanics I	Theoretical: 50	03
	CEMDSC406P		Practical: 50	02
MOLECULAR SPECTROSCOPY	**CEMDSC407T**	Unit-1: NMR Spectroscopy Unit-2: UV & IR Spectroscopy Unit-3: Rotational Spectroscopy Unit-4: Vibrational & Raman Spectroscopy	Theoretical: 50	04
	TUTORIAL		Tutorial: 50	01

SEMESTER V

Paper	Course ID	Course Content	Marks	Total Credit
INORGANIC CHEMISTRY 2	**CEMDSC508T**	Unit-1: Chemistry of *s* and *p* Block Elements (Group 1, 2, 13, 14 & 15) Unit-2: Chemistry of p-Block Elements (Group 16, 17 & 18) Unit-3: Transition Elements and M-M Bonding Unit-4: Coordination Chemistry-I	Theoretical: 50	03
	CEMDSC508P		Practical: 50	02
ORGANIC CHEMISTRY 2	**CEMDSC509T**	Unit-1: Carbonyls and Related Compounds Unit-2: Organometallics Unit-3: Nitrogen Compounds Unit-4: Rearrangements	Theoretical: 50	03
	CEMDSC509P		Practical: 50	02
PHYSICAL CHEMISTRY 2	**CEMDSC510T**	Unit-1: Surface Phenomenon Unit-2: Electrical properties Unit-3: Quantum Chemistry II Unit-4: Photochemistry	Theoretical: 50	03
	CEMDSC510P		Practical: 50	02
ANALYTICAL TECHNIQUES IN CHEMISTRY	**CEMDSC511T**	Unit-1: Qualitative and quantitative aspects of analysis Unit-2: Flame Atomic Absorption and Emission Spectrometry Unit-3: Quantitative Analysis Unit-4: Analytical Techniques	Theoretical: 50	04
	TUTORIAL		Tutorial: 50	01

SEMESTER VI

Paper	Course ID	Course Content	Marks	Total Credit
INORGANIC CHEMISTRY 3	**CEMDSC612T**	Unit-1: Coordination Chemistry-II Unit-2: Coordination Chemistry-III Unit-3: Bioinorganic Chemistry – I Unit-4: Organometallic Chemistry I	Theoretical: 50	03
	CEMDSC612P		Practical: 50	02
ORGANIC CHEMISTRY 3	**CEMDSC613T**	Unit-1: Pericyclic Chemistry Unit-2: Polynuclear Aromatic Hydrocarbons (PAHs) and Fullerenes Unit-3: Retro-synthetic Strategy in Organic Synthesis Unit-4: Chemistry of Cyclic Compounds	Theoretical: 50	03
	CEMDSC613P		Practical: 50	02
PHYSICAL CHEMISTRY 3	**CEMDSC614T**	Unit-1: Chemical Thermodynamics-III Unit-2: Quantum Chemistry III Unit-3: Statistical Thermodynamics Unit-4: Solid state	Theoretical: 50	03
	CEMDSC614P		Practical: 50	02
GREEN & APPLICATION ORIENTED CHEMISTRY	**CEMDSC615T**	Unit-1: Introduction to Green Chemistry Unit-2: Examples of Green Synthesis including some real world cases Unit-3: Chemistry in Daily life Unit-4: Environment Related Chemistry	Theoretical: 50	04
	TUTORIAL		Tutorial: 50	01

SEMESTER VII

Paper	Course ID	Course Content	Marks	Total Credit
ADVANCED INORGANIC CHEMISTRY 1	**CEMDSC716T**	Unit-1: Bioinorganic Chemistry-II Unit-2: Reaction Kinetics and Mechanism Unit-3: Organometallic Chemistry II Unit-4: Organometallics and f-block elements	Theoretical: 50	03
	CEMDSC716P		Practical: 50	02
ADVANCED ORGANIC CHEMISTRY 1	**CEMDSC717T**	Unit-1: Heterocyclic Compounds Unit-2: Carbohydrates Unit-3: Amino acids, Peptides and Proteins Unit-4: Bioorganic Chemistry Related to some Bio-molecules I	Theoretical: 50	03
	CEMDSC717P		Practical: 50	02

SEMESTER VIII

Paper	Course ID	Course Content	Marks	Total Credit
ADVANCED PHYSICAL CHEMISTRY 1	**CEMDSC818T**	Unit-1: Symmetry and Group Theory Unit-2: Electrochemistry Unit-3: Quantum Chemistry IV Unit-4: Theoretical Spectroscopy	Theoretical: 50	03
	CEMDSC818P		Practical: 50	02
ADVANCED INORGANIC CHEMISTRY 2	**CEMDSC819T**	Unit-1: General Principles of Metallurgy Unit-2: Silicate Industries Unit-3: Batteries and Alloys Unit-4: Fertilizers and Chemical explosives	Theoretical: 50	03
	CEMDSC819P		Practical: 50	02
ADVANCED ORGANIC CHEMISTRY 2	**CEMDSC820T**	Unit-1: Asymmetric Synthesis Unit-2: Natural Products Unit-3: Bioorganic Chemistry Related to some Bio-molecules II Unit-4: Reagents in Organic Synthesis	Theoretical: 50	03
	CEMDSC820P		Practical: 50	02
ADVANCED PHYSICAL CHEMISTRY 2	**CEMDSC821T**	Unit-1: Introduction to Polymer Chemistry Unit-2: Kinetics and Application of Polymers Unit-3: Nanomaterials-1 Unit-4: Nanomaterials-2	Theoretical: 50	03
	CEMDSC821P		Practical: 50	02
RESEARCH	**CEMRES801M**			15

Major (Core Course) for HONOURS in CHEMISTRY

SEMESTER-I

CEMDSC101T FUNDAMENTALS OF CHEMISTRY 1 Credits: 03

Theory Marks: 50

All Units carry equal marks

Unit-1: Atomic Structure and chemical periodicity

Atomic Structure - Bohr's theory for hydrogen atom (simple mathematical treatment), its limitations and atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, Aufbau principle and its limitations. Wave mechanics: de Broglie wave equation, Qualitative idea of Heisenberg's Uncertainty Principle. Radial and Angular distribution curves.Shapes of s, p and d orbitals. Exchange energy (qualitative idea).

Chemical periodicity -Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases.

Unit-2: Basics of Organic chemistry

Nomenclature for acyclic compounds only (trivial and IUPAC), DBE, hybridization(sp", n= 1,2,3) of C, N, O, halogens, bond distance, bond angles, VSEPR, shapes of molecules, inductive and field effects, bond energy, bond polarity and polarizability, dipole moment, resonance, resonance energy, steric inhibition of resonance, hyperconjugation, $\boldsymbol{\pi}$-M.O diagrams of ethylene, butadiene, 1,3,5- hexatriene, allylcation, allyl anion, allyl radical, HOMO and LUMO in ground and excited states, orbital pictures of allene, carbene(singlet and triplet), vinyl cyanide, Huckel's rule for aromaticity and antiaromaticity (neutral systems 4,6,8,10 annulene, charged systems 3,4,5,7 rings, Frost-diagram, melting point, boiling point, heat of hydrogenation, heat of combustion, hydrogen bonding (intra- and inter-molecular), crown-ether, concepts of acidity, basicity. Reaction intermediates: structure and stability of carbocation, carbanion, radicals, carbene & nitrene.

Unit-3: Kinetic Theory and Gaseous state

Kinetic Theory of gases: Concept of pressure and temperature; Maxwell's distribution of speed and energy: Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; calculations of average, root mean square and most probable values in each case; Graphical comparison of velocity and energy distribution.

Collision of gas molecules: Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar molecules); Rate of collision on wall and rate of effusion. Viscosity of gases from kinetic theory of gas.

Real gas and virial equation: Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; virial equation of state; van der Waals equation expressed in virial form and the significance of second virial coefficient.

CEMDSC101P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. **Preparation of Standard solutions**

a) Primary Standard: $K_2Cr_2O_7$, Oxalic Acid

b) Secondary Standard: $KMnO_4$, $Na_2S_2O_3$, Mohr's Salt

2. **Standardization of Secondary Standard Solution: ($KMnO_4$, $Na_2S_2O_3$, Mohr's Salt)**

3. **Systematic identification of a pure, solid organic compound.**

   Determination of solubility of solid organic compounds in water (cold and hot), dilute HCl, dilute NaOH and saturated solution of sodium bicarbonate.

   Systematic identification of oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, sucrose, benzoic acid and salicylic acid.

4. Determination of molecular properties of liquids

a. Study of viscosity of unknown liquid (glycerol, sugar) with respect to water.

b. Determination of relative surface tension of a liquid using Stalagmometer

SEMESTER-II

CEMDSC202T FUNDAMENTALS OF CHEMISTRY 2 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit-1: Acid-Base reactions

Acid-Base concept: Arrhenius concept, theory of solvent system (H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling's rules. Lux-Flood concept, Lewis concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Superacids, proton affinity; HSAB principle. Acid-base equilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer. Acid-base neutralization curves; indicator, choice of indicators. Solubility product, common ion effect and their application in analytical chemistry. (Gr. II A, B & Gr. III A, B).

Unit-2: Stereochemistry

Stereochemistry of acyclic compounds: representation of molecules in Fischer, flying- wedge, Sawhorse and Newman formula and their translations, chirality, elements of symmetry, simple axis (C_n), plane of symmetry(σ), centre of symmetry(i), alternating axis of symmetry (S_n), asymmetry and dissymmetry, optical activity, specific rotation, molar rotation, specific rotation of mixture, Biot's law. Stereoisomerism: enantiomerism, diastereoisomerism, stereogenic centre, systems with chiral centres, stereogenic centres involving C=C, C=N, D/L, R/S, E/Z, syn/anti, cis/trans, meso/dl, threo/erythro nomenclature

Conformation: conformational nomenclature; eclipsed, staggered, gauche and anti, dihedral angle, torsional angle, Klyne-Prelog terminology, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, hydrogen bonding, conformational analysis of ethane, propane, n-butane, 1,2-dihaloethane, 2-methylbutane, 1.2-glycols, invertomerism of trialkyl amines

Unit-3: Chemical kinetics

Rate law, order and molecularity: Introduction of rate law, Extent of reaction; rate constants, order; Forms of rates of 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.

Role of T and theories of reaction rates: Temperature dependence of rate constant; Arrhenius equation, energy of activation; Rate-determining step and steady-state approximation –

explanation with suitable examples; Collision theory; outline of Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)

Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis.

CEMDSC202P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. **Acid-Base Titration:**
   a) NaOH– Na_2CO_3 mixture
   b) Na_2CO_3 – $NaHCO_3$ mixture
   c) Oxalate – Oxalic Acid mixture
2. **Systematic identification of a pure, liquid organic compound.**
   Determination of miscibility of liquid organic compounds in water (cold and hot), dilute HCl, dilute NaOH and saturated solution of sodium bicarbonate.

   Systematic identification of formic acid, acetic acid, methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene.

   Determination of melting point of pure, solid organic compound (m.p. should be within 150^{o}C).

3. **Study of kinetics of simple chemical reactions**
   a. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate
   b. Study of kinetics of decomposition of H_2O_2

SEMESTER-III

CEMDSC303T CHEMICAL REACTION: PROPERTIES AND ENERGETICS Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Chemical periodicity (II) and redox reactions

Chemical periodicity (II): Effective nuclear charge, screening effects and penetration, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, lanthanide contraction. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) and factors influencing these properties, group electronegativities. Group trends and periodic trends in these propertiesin respectof s-, p- and d-block elements. Secondary periodicity, Relativistic Effect, Inert pair effect.

Redox reactions: Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators, Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions.

Unit-2: Substitution, Elimination Reactions and Reaction Kinetics

Nucleophilic substitution reactions: Substitution at sp^3centre: mechanisms (with evidence), relative rates &stereochemical features: SN1, SN2, SN2', SN1' (allylic rearrangement) and SNi; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP; role of crown ethers and phase transfer catalysts; [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides].

Aliphatic electrophilic substitution: Basic concept, S_E1, S_E2, S_ei

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

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

Tautomerism: Prototropy (keto-enol, nitro - *aci*-nitro, nitroso-oximino, diazo-amino and (enamine-imine systems), factors affecting keto-enol tautomerism.

Unit 3: Chemical Thermodynamics I

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

Thermochemistry: Standard states; Heats of reaction, solution, combustion, formation of molecules, neutralization; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations.

Second Law: Statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of $\oint dQ/T$ and Clausius inequality; Entropy change of systems and surroundings for various processes and transformations; Entropy and unavailable work.

CEMDSC303P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. **Estimation of concentration of Inorganic compounds**
   A. Estimation of Fe(II) using $K_2Cr_2O_7$ solution
   B. Estimation of Fe(II) using standardized $KMnO_4$ solution
   C. Estimation of Fe(III) using $K_2Cr_2O_7$ solution.
   D. Iodometric estimation of Cu^{2+}

2. **Organic**

Separation of the components of a binary mixture of solid organic compounds exploiting the principle of difference in solubility. Purification of any one of the separated components by crystallization and determination of its melting point. The binary mixture should consist of one acidic and one neutral compound and/or one basic and one neutral compound.

Determination of boiling point of a pure, liquid organic compound. (boiling point should be within 150^{o}C).

3. **Physical Experiment**

A: Determination of heat of neutralization of a strong acid (HCl) by a strong base (NaOH).

B: Determination of heat of neutralization of a weak acid (AcOH) by a strong base (NaOH).

C: Determination of heat of solution of Benzoic acid in water

SEMESTER-IV

CEMDSC404T INORGANIC CHEMISTRY 1 Credits: 03

Theory Marks: 50

All Units carry equal marks

Unit I: Radioactivity

Natural radioactivity, Radioactive decay law, half-life, average life, Soddy Fajan's Group displacement law, Radioactive equilibrium, Nuclear stability and nuclear binding energy. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers, Nuclear Reactions, Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Separation and uses of isotopes. Radiochemical methods: principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures.

Unit II: Chemical Bonding-I

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elementary idea). Solubility energetics of dissolution process

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Intermolecular forces: Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points.

Unit III: Chemical bonding II

Chemical Bonding-II: Covalent bond: Polarizing power and polarizability, ionic potential, Fajan's rules. Lewis structures, formal charge. Valence Bond Theory. The hydrogen molecule (Heitler-London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, Dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding (σ and π bond approach).

Shapes of f-orbitals, Ground state Term symbols of atoms and ions for atomic number up to 30.

Unit IV: Chemical Bonding-III

Molecular orbital theory: Concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO)) (elementary pictorial approach): sigma and pi- bonds and delta interaction, multiple bonding. Orbital designations: *gerade*, *ungerade*, HOMO, LUMO. Orbital mixing. MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO^+, CN^-, HF, BeH_2, CO_2 and H_2O. Bond properties: bond orders, bond lengths.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids

CEMDSC404P **Practical** **Credits: 02**

(60 Lectures/Contact hours) **Marks: 50**

1. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$.solution.
2. Estimation of Fe(III) and Mn(II) in a mixture using standardized $KMnO_4$ Solution and sodium bismuthate as oxidant
3. Estimation of Fe(III) and Cu(II)in a mixture using $K_2Cr_2O_7$.
4. Estimation of Fe(III)and $Cr_2O_7^{2-}$in a mixture using $K_2Cr_2O_7$.
5. Estimation of Cu(II) in brass.
6. Estimation of Fe_2O_3 in cement by using $KMnO_4$
7. Estimation (Gravimetry) of Ni(II) using dimethylglyoxime (DMG)
8. Estimation (Gravimetry) of Chloride
9. Estimation (Gravimetry) of Sulphate

CEMDSC405T ORGANIC CHEMISTRY 1 Credits: 03

Theory Marks: 50

All Units carry equal marks

Unit-1: Stereochemistry II

Chirality arising out of stereo-axis: 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 (R**a**/S**a** and P/M); atropisomerism; racemisation of chiral biphenyls; buttressing effect.

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Concept of prostereoisomerism: pro-stereogenic centre; concept of **(**pro**)-**n-chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Zand Re/Si descriptors; pro-R and pro-S descriptors of ligands on pro-pseudo-asymmetric centre.

Racemic compounds, racemization (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates); resolution of acids, bases and alcohols via diastereomeric salt formation; diastereomeric excess; optical purity and enantiomeric excess.

Unit-2: Chemistry of alkanes, alkenes, alkynes

Synthesis using the reactions *viz.* Wurtz reaction, Kolbe electrolysis, Corey-House synthesis, Decarboxylation, Hydrogenation. Chemical properties and reactions: Cracking or pyrolysis, Halogenation, Isomerization.

Synthesis using the reactions and methods *viz.* Dehydrohalogenation, Dehydration, Dehalogenation, Pyrolysis (ammonium hydroxides, acetates, xanthates), Wittig reaction, Cope elimination. Properties and Reactions of alkenes: Addition to 'C=C' bond: Mechanism (with evidence wherever applicable), Reactivity, Regioselectivity (Markownikoff and anti-Markownikoff additions) and Stereo selectivity. Hydrogenation, Halogenations, Iodolactonisation, Hydrohalogenation, Hydration, Oxymercuration-demercuration, Hydroboration-oxidation, Epoxidation, *syn*- and *anti*- hydroxylation, Ozonolysis, Carbene addition(singlet and triplet carbenes), Simmons-Smith reaction, Electrophilic addition to diene (conjugated dienes and allene), Radical addition of HX; Mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; Birch reduction of benzenoid aromatics; Interconversion of *E* - and *Z* - alkenes; contra-thermodynamic isomerization of internal alkenes.

Synthesis of alkynes: using vic- & gem- dihalides. Acidity of terminal alkynes, Formation and

reaction of acetylides. Addition to C≡C (in comparison to C=C): Mechanism, Reactivity and Selectivity. Hydrogenation, Addition of $X_2$and HX. Hydration and Oxidation to ketones and aldehydes (Hg^{2+} catalyzed, hydroboration-oxidation). Synthesis of Vinyl derivatives (Hg(II) and Cu(I) catalyzed reactions only). Dissolving metal reduction of alkynes (Birch reduction).

Unit-3: Aromatic Substitution Reactions and Phenols

Aromatic electrophilic substitution: Mechanism (S_E2, arenium ion, energy profile, *etc.*) and Evidences (Isotope effect, Isolation of intermediate); Example(s) of S_E1. Orientation and reactivity for mono-substituted benzene. Concept of orientation effect for di-substituted benzene. Reactions: Nitration, Nitrosation, Sulfonation, Halogenation, Friedel-Crafts reaction; one-carbon electrophiles (Reactions: chloromethylation, Gatterman-Koch, Gatterman, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); Ipso-substitituion.

Aromatic Nucleophilic substitution: Addition-elimination mechanism (S_NAr) and evidence; SN1 mechanism; Elimination-addition mechanism: Benzyne, Evidence and Structure of Benzyne; cine substitution.

Phenols: Synthesis (from Halobenzene, Cumene, Diazonium salt, Sulphonic acid); Acidic character. Reactions: Ring substitution, Kolbe, Reimer-Tieman, Formation of ether and Claisen rearrangement, Formation of ester and Fries rearrangement. Dihydric phenols: Dakin reaction, Formation of Quinol & Quinone. Reaction of p-benzoquinone: Addition reaction, Thiele acetylation. Quinhydrones (basic concept only).

Unit-4: Alcohols, Ethers, Carboxylic acids and their derivatives

Alcohols and Ethers: Structure and general properties of Alcohols: Boiling point, Polarity, Solubility, Acidity.Synthesis: Bouveault-Blanc reduction to1^0, 2^0 alcohols, Metallic hydride reduction ($NaBH_4$, LAH), Industrial preparation of Methanol (from CO and H_2), Concept of Fermentation of Carbohydrates for the formation of alcohols like Ehtanol. Reaction of alcohols: Hydrohalic acids, Oxidation to carbonyls and carboxylic acids (use of Chromic acid and/or Jones oxidation, $KMnO_4$, PCC, PDC). Differentiation of 1^0, 2^0 and 3^0 alcohols by Oxidation, Lucas test and using heated Cu at 300 ^{0}C.

General properties of Ethers: Boiling point, Polarity, Solubility, Usability as solvents. Synthesis and Reactions of Ethers: Synthesis from alcohols (in acidic medium, using diazomethane), Williamson's synthesis; Cleavage of Ethers by acids in hot and cold conditions. Hydrolysis of enol-ethers.

Carboxylic acids and their derivatives: General methods of synthesis of carboxylic acids. Preparation of Acyl halides, Esters, Anhydrides and Amides from Carboxylic acids. Mechanism (with evidence): *B*AC2, *A*AC2, *A*AC1, *A*AL1 (in connection to esterification of and hydrolysis of ester); Comparisons of reactivity and hydrolysis of Amides, Anhydrides, Acylhalides and esters.

CEMDSC405P **Practical** **Credits: 02**

(60 Lectures/Contact hours) **Marks: 50**

Qualitative Analysis of Single Solid Organic Compounds

A. Detection of special elements (N, S, Cl) by Lassaigne's test

B. Solubility and classification (solvents: H_2O, 5% HCl, 5% NaOH and 5% $NaHCO_3$)

C. Detection of the following functional groups by systematic chemical tests: aromatic amino ($-NH_2$), aromatic nitro ($-NO_2$), amido ($-CONH_2$, including imide), anilido (ArNHCO-), phenolic –OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O), olefinic unsaturation and ester (-COOR). Only one test for each functional group is to be reported.

D. Determination of the melting point of the given compound.

E. Preparation, purification and determination of melting point of a crystalline derivative of the given compound

F. Identification of the compound through literature survey.

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups with relevant derivatization in known and unknown (at least six) organic compounds.

Preparation of organic compounds following green methodology

a. Benzoylation of aromatic amines sans alkali.
b. Preparation of benzilic acid from benzil
c. Preparation of azomethines using mechano-chemical protocol.

CEMDSC406T PHYSICAL CHEMISTRY 1 Credits: 03

Theory Marks: 50

All Units carry equal marks

Unit I: Chemical Thermodynamics-II

Thermodynamic relations: Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium. Maxwell's relations; Gibbs-Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas.

Partial properties and Chemical potential:

Chemical potential and activity, partial molar quantities, relation between Chemical potential and Gibbs free energy and other thermodynamic state functions; variation of Chemical potential (μ) with temperature and pressure; Gibbs-Duhem equation; fugacity and fugacity coefficient; Variation of thermodynamic functions for systems with variable composition; Equations of states for these systems, Change in G, S, H and V during mixing for binary solutions.

Chemical potential and other properties of ideal substances- pure and mixtures: a) Pure ideal gas-its Chemical potential and other thermodynamic functions and their changes during a change of Thermodynamic parameters of mixing; Chemical potential of an ideal gas in an ideal gas mixture; Concept of standard states and choice of standard states of ideal gases.

Unit II: Chemical and Ionic Equilibrium: Degree of advancement of reaction and variation with free energy; van't Hoff's reaction isotherm (deduction from chemical potential); Equilibrium constant and standard Gibbs free energy change; Definitions of K_P, K_C and K_X; van't Hoff's reaction isobar and isochore from different standard states;

Shifting of equilibrium and value of equilibrium constant due to change in external parameters e.g. temperature and pressure; with respect to addition of inert gas; Le Chatelier's principle and its derivation.

Chemical potential of an ion in solution; Activity and activity coefficients of ions in solution; Debye-Hückel limiting law (qualitative idea), Estimation of activity coefficient for electrolytes using Debye-Hückel limiting law; Applications of the equation and its limitations.

Unit III: Transport Phenomenon

Fick's law: Flux, force, phenomenological coefficients & their inter-relationship (general form with examples).

Viscosity: General features of fluid flow (streamline flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation; Principle of determination of viscosity coefficient of liquids using Stoke's law (no derivation); Temperature variation of viscosity of liquids and comparison with that of gases.

Conductance and transport number: Conductance and its measurement, cell constant, specific conductance, equivalent conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent/ molar conductance at infinite dilution and their determination for strong and weak electrolytes; Ostwald's dilution law; Ionic mobility.

Application of conductance measurement: determination of solubility product, ionic product of water; conductometric titrations, Transport number, Hittorf's rule (no numericals) and Moving-boundary method.

Unit IV: Quantum Mechanics I

Beginning of Quantum Mechanics: Black-body radiation and Planck's theory of radiation; Light as particles: photoelectric and Compton effects; electrons as waves; Wave-particle duality: de Broglie hypothesis, Uncertainty relations (without proof).

Wavefunction: Schrödinger time-independent equation; nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function (Postulate-I); Orthogonal and normal functions.

CEMDSC406P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1.Conductometric titration of a mixed/dibasic acid against strong base (NaOH).

2. Conductometric titration of a weak monobasic acid (AcOH) against a strong base (NaOH).

3. To study the kinetics of saponification reaction conductometrically.

4. Verification of Ostwald's dilution law and determination of K_a of weak acid.

5. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator)

CEMDSC407T MOLECULAR SPECTROSCOPY Credits: 04

Theory **Marks: 50**

Tutorial **Credit: 01** **Marks: 50**

All Units carry equal marks

Unit 1: NMR Spectroscopy

Introduction to nuclear spin, NMR active molecules; basic principles of Proton Magnetic Resonance; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR ; elementary idea about non-first-order splitting; anisotropic effects in alkene, alkyne, aldehydes and aromatics; NMR peak area, integration; relative peak positions with coupling patterns of common organic compounds (both aliphatic and benzenoid-aromatic); rapid proton exchange; interpretation of NMR spectra of simple compounds.

Unit 2: UV & IR Spectroscopy

UV- spectroscopy: Introduction; types of electronic transitions, end absorption; transition dipole moment and allowed/forbidden transitions; chromophores and auxochromes; Bathochromic and Hypsochromic shifts; intensity of absorptions (Hyper/Hypochromic effects); application of Woodward's Rules for calculation of λ_{max} for the following systems: conjugated diene, α,β-unsaturated aldehydes and ketones (alicyclic, homo-annular and hetero-annular); extended conjugated systems (dienes, aldehydes and ketones); relative positions of λ_{max} considering conjugative effect, steric effect, solvent effect, effect of pH; effective chromophore concentration: keto-enol systems; benzenoid transitions. Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.

IR Spectroscopy: Introduction; modes of molecular vibrations (fundamental and nonfundamental); IR active molecules; application of Hooke's law, force constant; fingerprint region and its significance; effect of deuteration; overtone bands; vibrational coupling in IR; characteristic and diagnostic stretching frequencies of C-H, N-H, O-H, CO, C-N, C-X, C=C (including skeletal vibrations of aromatic compounds), C=O, C=N, N=O, C≡C, C≡N; Characteristic stretching frequency of metal-nitrogen, metal oxygen, metal-sulphur bonds in simple inorganic metal complexes with organic ligands, characteristic/diagnostic bending vibrations are included; factors affecting stretching frequencies: effect of conjugation, electronic effects, mass effect, bond multiplicity, ring-size, solvent effect, H-bonding on IR absorptions; application in functional group analysis.

Unit 3: Rotational Spectroscopy

Rotation of molecules, Classification of molecules based on principal moments of inertia, Example of prolate and oblate symmetric top molecules, Rigid rotor approximation and moment of inertia of a rigid diatomic molecule, selection rule and intensity of spectral lines, effect of centrifugal distortion and the spectrum of non-rigid rotor, determination of bond lengths of diatomic molecules, effect of isotopic substitution, principle of microwave oven.

Unit 4: Vibrational & Raman Spectroscopy

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies; Diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

SEMESTER-V

CEMDSC508T INORGANIC CHEMISTRY 2 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Chemistry of *s* and *p* Block Elements (Group 1, 2, 13, 14 and 15)

Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Beryllium hydrides and halides. Boric acid and borates, boron nitrides, borohydrides (diborane) and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, phosphorus. Synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates, aluminosilicates, zeolites and phosphazenes.

Unit 2: Chemistry of p-Block Elements (Group 16, 17 and 18)

Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Oxides and oxoacids of Sulphur and chlorine. Peroxoacids of sulphur, sulphur-nitrogen compounds, inter-halogen compounds, polyhalide ions, pseudohalogens, fluorocarbons and basic properties of halogens.

Noble Gases:
Occurrence and uses, rationalization of inertness of noble gases, peculiar behavior of liquid helium, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2 and XeF_4). Xenon-oxygen compounds. Molecular shapes of noble gas compounds (VSEPR theory).

Unit 3: Transition Elements and M-M Bonding

General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry. Comparative study of Cu, Ag and Au and Zn, Cd and Hg. Structure and Bonding of Dinuclear Complexes: e.g. $(Re_2Cl_8)^{2-}$, Preliminary concept of Crutz Taube Complex (Mixed valence complexes)

Unit 4: Coordination Chemistry-I

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

CEMDSC508P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

(A) Complexometric titration

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

(B) Inorganic preparations

1. *Cis* and *trans* $K[Cr(C_2O_4)_2(H_2O)_2]$
2. Tetraamminecarbonatocobalt(III) ion
3. Potassiumtris(oxalato)ferrate(III)
4. Tris-(ethylenediamine) nickel(II) chloride.
5. $[Mn(acac)_3]$and $Fe(acac)_3]$ (acac= acetylacetonate)

CEMDSC509T ORGANIC CHEMISTRY Credits: 03

Theory Marks: 50

All Units carry equal marks

Unit-1: Carbonyl and Related Compounds

Structure, Reactivity and Preparation of carbonyl compounds; Addition to C=O: mechanism (with evidence), reactivity, equilibrium and kinetic control; formation of hydrates, cyanohydrins and bisulphate adduct; nucleophilic addition-elimination reactions with alcohols, thiols and nitrogen based nucleophiles; reactions: benzoin condensation, Cannizzaro and Tischenko reactions, reactions with ylides: Wittig and Corey-Chaykovsky reaction; Rupe rearrangement, Oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, Oppenauer, Bouveault-Blanc, acyloin condensation, periodic acid and lead tetraacetate oxidation of 1,2-diols.

Exploitation of acidity of α-H of C=O:formation of enols and enolates; kinetic and thermodynamic enolates; reactions (mechanism with evidence): halogenation of carbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (H. V. Z.) reaction, nitrosation, SeO_2 (Riley) oxidation; condensations (mechanism with evidence): Aldol, Tollen's, Doebner condensation, Knoevenagel, Claisen-Schmidt, Claisen ester including Dieckmann, Stobbe; Mannich reaction, Perkin reaction, specific enol equivalents (lithium enolates, enamines, aza-enolates and silylenol ethers) in connection with alkylation, acylation and aldol type reaction.

Nucleophilic addition to α, β-unsaturated carbonyl system: general principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction). Substitution at sp2 carbon (C=O system).

Unit-2: Organometallics

Grignard reagent; Organolithiums; Gilman cuprates: Preparation and Reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; alkylation, substitution on -COX; directed orthometalation of arenes using organolithiums, conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behavior of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; Blaise reaction; concept of umpolungand base-nucleophile dichotomy in case of organometallic reagents.

Unit 3: Nitrogen compounds

Amines: Aliphatic & Aromatic: preparation, separation (Hinsberg's method) and identification of primary, secondary and tertiary amines; reaction (with mechanism): Eschweiler–Clarke methylation, diazo coupling reaction, Diazonium salts and their related compounds: reactions (with mechanism) involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp-Klingermann. formation and reactions of phenylenediamines, diazomethane and diazoacetic ester.

Nitro compounds (aliphatic and aromatic): preparation and reaction (with mechanism): reduction under different conditions; Nef carbonyl synthesis, Henry reaction and conjugate addition of nitroalkane anion, reaction with nitrous acid.

Alkylnitrile and isonitrile: preparation and reaction (with mechanism): Thorpe nitrile condensation, von Richter reaction.

Unit 4: Rearrangements

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

Rearrangement to electron-deficient nitrogen: Hofmann, Curtius, Lossen, Schmidt and Eckmann.

Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, cumene hydroperoxide-phenol rearrangement and Dakin reaction.

Aromatic rearrangements: Migration from oxygen to ring carbon: Fries rearrangement and Claisen rearrangement.

Migration from nitrogen to ring carbon: Fischer Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement, benzidine rearrangement.

Favorskii rearrangement, Piancatelli rearrangement.

CEMDSC509P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Quantitative Estimations of organic compounds:

1. Estimation of glycine by Sörensen's formol method
2. Estimation of glucose by titration using Fehling's solution
3. Estimation of sucrose by titration using Fehling's solution
4. Estimation of vitamin-C (reduced)
5. Estimation of aniline by bromination (Bromate-Bromide) method
6. Estimation of saponification value of oil/fat/ester.

TLC separation of a mixture containing:

1. 2/3 amino acids
2. 2 dyes (fluorescein and methylene blue)

CEMDSC510T PHYSICAL CHEMISTRY 2 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit I: Surface Phenomenon

Surface tension and energy: Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading of liquid over other surface; Vapour pressure over curved surface; Temperature dependence of surface tension.

Adsorption: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess.

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.

Unit-II: Electrical properties

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, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass.

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Dipole moment and polarizability: Polarizability of atoms and molecules, Clausius-Mosotti equation and Debye equation (both without derivation) and their application.

Unit III: Quantum Chemistry II

Concept of Operators: Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators; Commutation of operators, commutator and uncertainty relation; Expectation value; Hermitian operator; Postulates of Quantum Mechanics.

Particle in a box: Setting up of S.E. for one-dimensional well and its solution; Comparison with free particle eigenfunctions and eigenvalues. Properties of PB wave functions (normalization, orthogonality, probability distribution); Expectation values of x, x^2, $p_x$and $p_x^2$and their significance in relation to the uncertainty principle; Extension of the problem to two and three dimensions and the concept of degenerate energy levels.

Unit IV: Photochemistry

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

Photochemical Processes: Potential energy curves (diatomic molecules), Born-Oppenheimer approximation; Frank-Condon principle and vibrational structure of electronic spectra; Bond dissociation and principle of determination of dissociation energy (ground state); Decay of excited states by radiative and non-radiative paths; Pre-dissociation; Fluorescence and phosphorescence, Jablonskii diagram.

Rate of Photochemical processes: Photochemical equilibrium and the differential rate of photochemical reactions, Photostationary state; HI decomposition, photostationary states, dimerization of anthracene.
Photosensitized reactions and chemiluminescence (only elementary idea).

CEMDSC510P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. Verification of Beer's Law for $KMnO_4$ solution.

2. Verification of Beer's Law for $K_2Cr_2O_7$ solution.

3. Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$ solution.

4. Determination of K_{sp} for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution.

CEMDSC511T ANALYTICAL TECHNIQUES IN CHEMISTRY Credits: 04

Theory **Credits: 04** **Marks: 50**

Tutorial **Credits: 01** **Marks: 50**

All Units carry equal marks

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 in determinate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

UNIT 2: Flame Atomic Absorption and Emission Spectrometry

Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs). Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

UNIT 3: Quantitative analysis

Basic principles of quantitative analysis by UV-Vis spectrophotometry
Estimation of metal ions from aqueous ssolution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation, slope ratio and mole ratio method.

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

UNIT 4: Analytical Techniques

Thermal methods of analysis: Theory of thermogravimetry (TG), basic principle of instrumentation. Interpretation of TGA curve for example Ca-oxalate monohydrate. Techniques for quantitative estimation of Ca and Mg from their mixture.

Electrochemical Methods: Electrochemical cell, different kinds of electrodes, Pt-electrode, glassy-carbon electrode, membrane electrodes

Polarography: Basic principle – polarized and depolarized electrodes; diffusion currents, Dropping mercury electrode, polarographic wave; Ilkovic equation (no derivation) and its significance; half wave potential.

Cyclic voltammetry: Basic principles, three electrode system, reversible, quasi reversible, irreversible cyclic voltammograms

SEMESTER-VI

CEMDSC612T INORGANIC CHEMISTRY 3 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Coordination Chemistry-II

VB description and its limitations. Elementary Crystal Field Theory: splitting of d^nconfigurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn-Teller distortion. Octahedral site stabilization energy (OSSE). Structure of spinel (normal and inverted) Metal-ligand bonding (MO concept, elementary idea), sigma-and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals(examples).

Unit 2: Coordination Chemistry-III

Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments including orbital contribution; quenching of magnetic moment; super exchange and anti-ferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea).

Unit 3: Bioinorganic Chemistry -I

Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}). Metal ion transport across biological membrane Na^+/K^+-ion pump. Dioxygen molecule in life. Dioxygen management proteins: Haemoglobin, Myoglobin, Hemocyanine and Hemerythrin.

Unit 4: Organometallic Chemistry I

Definition and classification of organometallic compounds on the basis of bond type. Concept to hapticity of organic ligands.18-electron and 16-electron rules (pictorial MO approach). Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls. π-acceptor behavior of CO, synergic effect and use of IR data to explain extent of back bonding.

CEMDSC612P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Qualitative analysis of Inorganic Samples using Dry tests, Wet tests and special tests with HCl, HNO_3 and NaOH extracts. The sample should contain **four radicals** and must be **water soluble and/or HCl soluble.**

Cation Radicals: Na^+, K^+, Ca^+, Sr^+, Ba^{2+}, Al^{3+}, Cr^{3+}, Mn^{2+}/Mn^{4+}, Fe^{3+}, Co^{2+}/Co^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Cd^{2+}, Bi^{3+}, As^{3+}/As^{5+}, Sb^{3+}/Sb^{5+}, NH_4^+, Mg^{2+}
Anion Radicals: F^-, Cl^-, Br^-, BrO_3^-, I^-, IO_3^-, SCN^-, S^{2-}, SO_4^{2-}, SO_3^{2-}, NO_3^-, NO_2^-, $S_2O_3^{2-}$
(The interfering acid radicals and insoluble compounds are not included. Probable composition not required)

CEMDSC613T ORGANIC CHEMISTRY 3 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Pericyclic reactions

Mechanism, stereochemistry, regioselectivity in case of Electrocyclic reactions: FMO approach involving 4π- and 6π-electrons (thermal and photochemical) and corresponding cyclo-reversion reactions.

Cycloaddition reactions: FMO approach, Diels-Alder reaction, photochemical [2+2] cycloadditions. Substituent effects on Reactivity, Regioselectivity and Stereochemistry. Intramolecular Diels-Alder reaction. 1,3-dpolar cycloaddition.

Sigmatropic reactions: FMO approach, sigmatropic shifts and their order; [1,3]- and [1,5]-H shifts and [3,3]-shifts with reference to Claisen and Cope rearrangements, Oxy-Cope rearrangement. Stereochemistry of sigmatropic rearrangement.

Unit 2: Polycyclic Aromatic Hydrocarbons (PAHs) and Fullerenes

Polynuclear hydrocarbons and their derivatives: Synthetic methods including Haworth, Bardhan-Sengupta, Bogert-Cook and other useful syntheses (with mechanistic details). Structure(s), Stability, Canonical forms, Aromaticity of polybenzenoid hydrocarbons, Partial fixation of double bonds, Fries rule, Clar's rule. Reactions (with mechanism and comparison) of Naphthalene, Anthracene, Phenanthrene and their derivatives (Electrophilic substitution reactions, Oxidation and Reduction reactions, Bucherer reaction, Diels-Alder reaction, etc.).

Fullerenes: General structural features of C_{60} fullerene (Buckyball), aromatic-antiaromatic nature, elementary idea of properties and uses.idea about the other fullerenes.

Unit 3: Retro-synthetic Strategy in Organic Synthesis

Retrosynthetic analysis: disconnections; synthons, donor and acceptor synthons; natural reactivity and umpolung; latent polarity in bifunctional compounds: consonant and dissonant polarity; illogical electrophiles and nucleophiles; synthetic equivalents; functional group interconversion and addition (FGI and FGA); C-C disconnections and synthesis: one-group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl).

Active methylene compounds: Property and reactions in general. Preparation and synthetic applications of some active methylene compounds like diethyl malonate, ethyl acetoacetate, acetylacetone.

Strategy of protection-deprotection: Application of protection-deprotection chemistry for alcohols, amines, carbonyls and acids towards the synthesis of organic molecules.

Strategy of ring synthesis: thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique. Robinsons annulations.

Unit 4: Chemistry of Cyclic compounds

Alicyclic compounds: Relative stability of monocyclic alkanes (small, medium and large rings); Concept of I-strain**,** Cyclopropane, Cyclobutane, Cyclopentane.

Conformational analysis: Cyclohexane, mono and disubstituted cyclohexane; Geometry and Symmetry properties, Optical activity, *cis*-/*trans*- isomerism, ring inversion; Topomerisation, Ring-size and ease of cyclisation; Conformation & Reactivity in cyclohexane system: Consideration of steric and stereoelectronic requirements; Elimination (E2, E1), Nucleophilic substitution (SN1, SN2, SNi, NGP), Merged substitution-elimination; Rearrangements; Oxidation of cyclohexanol, Esterification, Saponification, Lactonisation, Epoxidation, Pyrolytic **syn** elimination and fragmentation reactions.

Conformational analysis and reactions of cyclohexanone*:* Reduction with metal hydrides, organometallic addition, cyanohydrins formation.

CEMDSC613P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Organic Preparations

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

1. Nitration of aromatic compounds under both cold and hot conditions.

2. Condensation reactions

3. Hydrolysis of amides/imides/esters

4. Acetylation of aromatic amines

5. Side chain oxidation of aromatic compounds

6. Selective reduction of *m*-dinitrobenzene to m-nitroaniline

7. Bromination of anilides using green approach (Bromate-Bromide method)

Students must also calculate percentage yield, based upon isolated yield (crude) and theoretical yield.

B. Purification of the crude product is to be made by crystallisation from water/alcohol.

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

CEMDSC614T PHYSICAL CHEMISTRY 3 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit I: Chemical Thermodynamics-III

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 the amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution; Abnormal colligative properties.

Phase rule: Definitions of phase, component and degrees of freedom; Phase rule and its derivations; Definition of phase diagram; Phase diagram for water, CO_2, Sulphur First order phase transition and Clapeyron equation; Clausius-Clapeyron equation - derivation and use; Liquid vapour equilibrium for two component systems; Phenol-water system.

Binary solutions: Ideal solution at fixed temperature and pressure; Duhem-Margules equation; Henry's law; Konowaloff's rule (principle of fractional distillation); Positive and negative deviations from ideal behavior; Azeotropic solution.

Unit II: Quantum Chemistry III

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component; Properties of angular momentum operators; Eigenfunctions of L_Z and L_Z^2; Rigid rotator model of rotation of diatomic molecule and Schrödinger equation; Transformation to spherical polar coordinates; Separation of variables; Spherical harmonics; Discussion of solution.

Simple Harmonic Oscillator: Setting up of the Schrodinger stationary equation, energy expression (without derivation); Concept of Zero Point Energy and tunneling. Expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic features.

Unit III: Statistical Thermodynamics

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

Boltzmann distribution: Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution; Concept of ensembles - canonical ensemble and grand canonical ensemble.

Partition function: Molecular partition function and thermodynamic properties (U, H, S, C_V, q, P); $q_{translation}$, $q_{vibration}$ and ideal gas equation.

Third-law of thermodynamics: Nernst heat theorem, Absolute entropy, Planck's law, Residual entropy, Adiabatic demagnetization.

Unit IV: Solid state

Bravais Lattice and Laws of Crystallography: Laws of crystallography; Permissible symmetry axes in crystals; Lattice, space lattice, unit cell, crystal planes, Bravais lattice.

Indexing of planes, Miller indices; Crystal planes: Distance between consecutive planes and void space [cubic lattices]; Relation between molar mass and unit cell dimension for cubic system; Bragg's law (derivation)

Determination of crystal structure: Structure of NaCl and KCl crystals.

Specific heat of solid: Dulong–Petit's law; Einstein's theory – derivation from partition function, limitations; Debye's T^3-law (no derivation) – analysis at the two extremes.

CEMDSC614P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Experiment 1: Study of kinetics of $K_2S_2O_8$/KI reaction colorimetrically/spectrophotometrically.

Experiment 2: Determination of pK_{in} of indicator (Bromocresol green) colorimetrically.

Experiment 3: Conductometric determination of CMC of SDS and effect of electrolytes.

Experiment 4: Study of phenol-water phase diagram.

CEMDSC615T APPLICATION ORIENTED CHEMISTRY

Theory **Credits: 04** **Marks: 50**

Tutorial **Credits: 01** **Marks: 50**

All Units carry equal marks

Unit1: Introduction to Green Chemistry

Introduction to Green chemistry: Need for Green Chemistry. Goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis*:* Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

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

Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, PEG, solventless processes.

Energy requirements for reactions – alternative sources of energy: use of Microwaves and Ultrasonic energy (Basic working principle)

Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.

Examples and Use (in the context of Green Chemistry) of catalytic reagents (wherever possible) in preference to stoichiometric reagents, Biocatalysis and Photocatalysis.

Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Unit 2: Examples of Green-synthesis including some real world cases

Green Synthesis of the following compounds: Adipic acid, Catechol, Disodium iminodiacetate (alternative to Strecker synthesis).

Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction.

Ultrasound assisted reactions: Sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.

Rightfit pigment: synthetic azo-pigments to replace toxic organic and inorganic pigments.
An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Future Trends in Green Chemistry: Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Green chemistry in sustainable development.

Unit 3: Chemistry in Daily Life

Dairy Products: Composition of milk and milk products. Analysis of fat content, minerals in milk and butter. Estimation of added water in milk.

Food additives, adulterants and contaminants: Food preservatives like benzoates, propionates, sorbates, disulphites. Addition of permitted and non-permitted colours and metallic salts. Analysis of pesticide residues in food.

Structure & use of Artificial sweeteners and Flavouring Agents: Aspartame, saccharin, dulcin, sucralose and sodium cyclamate. Vanillin, alkyl esters (fruit flavours) and monosodium glutamate.

Chemistry of cosmetics: Chemical Ingredients used in Sun screen, Toothpaste, Hair dye, Shampoo, Nail Polish, Talcum Powder, Perfumes.

Drugs: Pharmacological effect, drug action, synthesis and chemical structure (Aspirin, Metronidazole, Diclofenac, Penicillin, Paracetamol)

Unit 4: Environment Related Chemistry

Air Pollution: Air pollutants, prevention and control, Green house gases, NO_x, SO_x and acid rain. Ozone hole and CFC's. Photochemical smog and PAN. Catalytic converters for mobile sources.

Hydrologic cycle, sources, criteria and standards of water quality-safe drinking water. Public health significance and measurement of water quality parameters- (Colour, turbidity, total solids, acidity, alkalinity, hardness, sulphate, flouride, phosphate, nitrite, nitrate, BOD and COD). Water purification for drinking and industrial purposes.

Toxic chemicals in the environment. Detergents- pollution aspects, eutrophication. Pesticides and insecticides-pollution aspects. Heavy metal pollution. Solid pollutants- treatment and disposal. Treatment of industrial liquid wastes. Sewage and industrial effluent treatment.

Composition of soil – inorganic and organic components in soil-micro and macronutrients.

SEMESTER-VII

CEMDSC716T ADVANCED INORGANIC CHEMISTRY 1 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Bioinorganic Chemistry-II

Electron transfer proteins: Cytochromes and Ferredoxins. Hydrolytic enzymes: carbonate bicarbonate buffering system and carbonic anhydrase and carboxyanhydraseA. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II. Synthetic oxygen compound (Vaska's compound) Toxic metal ions and their effects, chelation therapy, Pt and Au complexes as drugs, metal dependent diseases

Unit 2: Reaction Kinetics and Mechanism

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

Unit 3: Organometallic Chemistry II

Zeise's salt: Preparation, structure, evidences of synergic effect. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertion reactions with examples.

Unit 4: Organometallics and f-block elements

Catalysis by Organometallic Compounds: Study of the following industrial processes: Alkene hydrogenation (Wilkinson's Catalyst), Wacker Process, Synthetic gasoline (Fischer Tropsch reaction), Ziegler-Natta catalysis for olefin polymerization.

Chemistry of f-block elements (Lanthanoids and Actinoids): General Comparison on Electronic configuration, oxidation states, colour, spectral and magnetic properties; lanthanide contraction, separation of lanthanides (ion-exchange method only).

CEMDSC716P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Qualitative Analysis of Inorganic Samples: The sample should contain **four radicals** and interfering acid radicals and insoluble compounds are included. Probable composition should be mentioned.

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

Anion Radicals: F^{-}, Cl^{-}, Br^{-}, BrO_3^{-}, I^{-}, IO_3^{-}, SCN^{-}, S^{2-}, SO_4^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_3^{-}, NO_2^{-}, PO_4^{-}, AsO_4^{3-}, BO_3^{3-}, CrO_4^{2-}, $Cr_2O_7^{2-}$, $Fe(CN)_6^{4-}$, $Fe(CN)_6^{3-}$

Insoluble samples: Al_2O_3(ignited), Fe_2O_3 (ignited), Cr_2O_3(ignited), SnO_2, SiO_2, $PbSO_4$, $SrSO_4$, $BaSO_4$, CaF_2

CEMDSC717T ADVANCED ORGANIC CHEMISTRY 1 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit-1: Heterocyclic compounds

Heterocycles: 5- and 6-membered rings with one heteroatom; reactivity, orientation and important reactions (with mechanism) of furan, pyrrole, thiophene and pyridine; synthesis (including retrosynthetic approach and mechanistic details): pyrrole: Knorr synthesis, Paal-Knorr synthesis, Hantzsch synthesis; furan: Paal-Knorr synthesis, Feist-Benary synthesis and its variation; thiophenes: Paal-Knorr synthesis, Hinsberg synthesis; pyridine: Hantzsch synthesis; benzo-fused 5- and 6-membered rings with one heteroatom: reactivity, orientation and important reactions (with mechanistic details) of indole, quinoline and isoquinoline; synthesis (including retrosynthetic approach and mechanistic details): indole: Fischer, Madelung and Reissert; quinoline: Skraup, Doebner Miller, Friedlander; isoquinoline: Bischler-Napieralski synthesis.

Unit-2: Carbohydrates

Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect (including stereo-electronic explanation); mutarotation; epimerization; reactions (mechanisms in relevant cases): Fischer glycosidation, osazone formation, bromine water oxidation, HNO3 oxidation, selective oxidation of terminal –CH2OH of aldoses, reduction to alditols, Lobry de Bruyn-van Ekenstein rearrangement; stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's &Wohl's methods) of aldoses; end-group interchange of aldoses; acetonide (isopropylidene) and benzylidene protections; ring-size determination; Fischer's proof of configuration of (+)-glucose.

Disaccharides: Glycosidic linkages, concept of glycosidic bond formation by glycosyl donor-acceptor; structure of sucrose, inversion of cane sugar.

Unit-3: Amino acids, Peptides and Proteins

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

Peptides and Proteins: Peptide linkage and its geometry; syntheses (with mechanistic details) of peptides using **N**-protection & C-protection, solid-phase (Merrifield) synthesis; peptide sequence: **C**-terminal (Carboxypeptidase, akabori and reduction methods) and **N**-terminal(Edman, Sanger & dansyl methods) unit determination; partial hydrolysis; specific cleavage of peptides: use of CNBr, trypsine and chymotrypsine, Structure of Proteins: Overview of Primary, Secondary, Tertiary and Quaternary structure. Example(s) and function(s) of Fibrous protein and Globular proteins, Denaturation.

Unit-4: Bioorganic Chemistry Related to Some Biomolecules-I

Pyrimidine and Purine bases (only structure & nomenclature). Structure of Nucleic acids: Nucleosides and Nucleotides corresponding to DNA and RNA; Other important nucleotides (ATP, structure and representative example(s) of its function) and dinucleotide (NAD+, FAD, NADPH, $FADH_2$, structures and only representative example(s) of their functions). Mechanism for acid catalyzed hydrolysis of nucleosides (both pyrimidine and purine types); Comparison of alkaline hydrolysis of DNA and RNA. Elementary idea of double helical structure of DNA (Watson-Crick model); Complimentary base–pairing in DNA. Brief introduction to DNA-replication and RNA-transcription. Elementary concept of functions of mRNA, rRNA and tRNA. Special mention of mRNA vaccine related to covid virus.

CEMDSC717P **Practical** **Credits: 02**

(60 Lectures/Contact hours) **Marks: 50**

Qualitative Analysis of Single liquid Organic Compounds

A. Detection of special elements (N, S, Cl) by Lassaigne's test

B. Miscibility and classification (solvents: H_2O, 5% HCl, 5% NaOH and 5% $NaHCO_3$)

C. Detection of the following functional groups by systematic chemical tests: aromatic amino (-NH_2, -NHR, -NR_2), aromatic nitro (-NO_2), nitrile (-CN), phenolic –OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O), and ester (-COOR). Only one test for each functional group is to be reported.

D. Determination of the boiling point of the given compound.

E. Preparation, purification and determination of melting point of a crystalline derivative of the given compound.

F. Identification of the compound through literature survey.

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups with relevant derivatisation in known and unknown (at least three) organic compounds.

Isolation of natural products:

a. Caffeine from tea leaves
b. Piperine from black pepper
c. Lycopine from tomatoes

SEMESTER-VIII

CEMDSC818T ADVANCED PHYSICAL CHEMISTRY 1 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Symmetry and Group Theory

Symmetry elements and operations; Classification of molecules; Group, subgroup etc., class, character; point groups, point group symbols; representations; great orthogonality theorem and its consequences; character table. Symmetry adapted linear combination (SALC) with illustrative examples.

Unit 2: Electrochemistry

Ion solvent interactions.Debye Hückel theory and its extension. Application of Debye Hückel theory – Limiting law, Debye Hückel Onsager theory and its extension. Debye-Falkenhagen effect, Wien effect. Gouy Chapman & Stern models.

Unit 3: Quantum Chemistry IV

Finite potential barrier problems (constant potential barrier on one side, and two sides), Quantum Tunneling, Variation Theorem.

Qualitative treatment of hydrogen atom and hydrogen-like ions: Setting up of S.E. in spherical polar coordinates, radial part, quantization of energy (only final energy expression); Plots of polar parts and radial distributions; Wavefunction of one electron atoms; Average and most probable distances of electron from nucleus; Setting up of Schrödinger equation for many-electron atoms (He, Li).

Unit 4: Theoretical Spectroscopy

General introduction, nature of electromagnetic interaction, shapes and width of spectral lines, intensity of spectral lines; Induced and spontaneous radiative processes, concept of Einstein A and B coefficients, Derivation of relation between Einstein coefficients. Mathematical concept of Transition moment integral with application to selection rules. Concept of Fourier transformation; Stark effect on molecular rotation spectra, Breakdown of Born-Oppenheimer approximation.

CEMDSC818P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. pH-metric titration of acid (mono- and di-basic) against strong base

2. Verification of Onsager equation using KCl.

3. Determination of pH of unknown buffer spectrophotometrically.

4. Determination of isosbestic point of BCG indicator spectrophotometrically.

5. Determination of isoelectric point of an amino acid.

CEMDSC819T ADVANCED INORGANIC CHEMISTRY 2 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: General Principles of Metallurgy

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

Unit 2: Silicate Industries

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

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

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

Unit 3: Batteries and Alloys

Batteries: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

Alloys: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (Air and heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

Unit 4: Fertilizers and Explosives

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.

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

CEMDSC819P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. Available oxygen in pyrolusite
2. Available chlorine in bleaching powder
3. Estimation of Ca and Mg in Dolomite
4. Estimation of Cr and Mn in steel

Calculation of error percentage in the above experiments

Spectrophotometry

5. Measurement of 10Dq by spectrophotometric method
6. To separate a mixture of Ni^{2+} and Fe^{3+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.
7. Determination of λ_{max} of $[Mn(acac)_3]$ and $[Fe(acac)_3]$ complexes.

CEMDSC820T ADVANCED ORGANIC CHEMISTRY 2 Credits: 03

Theory Marks: 50

All Units carry equal marks

Unit-1: Asymmetric synthesis

Principle of asymmetric synthesis. Concept of Substrate control, Chiral reagent. Definition and examples of 'chiral-pool' and 'chiral-auxiliaries', diastereoselectivity and enantioselectivity. Addition to 'C=O' and 'C=O' adjacent to a stereogenic centre: Burgi-Dunitz trajectory in nucleophilic additions; Cieplak model, Felkin-Anh and Zimmermann-Traxler models, Asymmetric aldol reaction, Reactions of enolates (α-substitution), Alkylation Epoxidation, dihydroxylation, mono-hydroxylation. Kinetically controlled MPV reduction, CBS and Noyori hydrogenation.

Unit-2: Natural products

Terpenoids: Natural sources, general structural features, isoprene rule, special isoprene rule. Elementary idea of structure elucidation (by chemical and spectroscopical methods). Introduction to mono-, di-, tri- and sesqui-terpenoids. Biosynthetic route to terpenoids. General features, synthesis, properties and reactions of some terpenoids: Citral, Geraniol, Neral and α-terpineol.

Alkaloids: Natural occurrence, general structural features. Familiarity with methods of structural elucidation (chemical and spetroscopical methods). Isolation, Physiological action, Structure elucidation, Hoffmann's exhaustive methylation, Emde's modification and synthesis: Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, and Reserpine.

Unit-3: Bioorganic Chemistry Related to Some Biomolecules-II

Enzymes: Classification and characteristics of enzymes. Salient features of active site of enzymes. Molecular recognition and Mechanism of enzyme action: Static and dynamic recognition, Lock and Key model, Induced fit model. Examples of hydrolysis of peptides by chymotrypsin (role of catalytic triad, oxyanion hole) in small intestine and conversion of pyruvate to lactic acid by lactate dehydrogenase in cytoplasm. Factors regulating enzyme action: enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition). Coenzymes and cofactors and their role in biological reactions.

Fats and oils: Introduction to fats and oils, common fatty acids present in fats and oils. Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Chemistry of cholesterol: Basic structural aspects. Concept LDL, HDL and VLDL.

Unit-4: Reagents in Organic Synthesis

One electron and two electron oxidants. Oxidations with Cr (VI): Jones oxidation, Collins oxidation PCC, PDC, PFC; DMSO based oxidations: Swern, Moffat, DMSO-SO_3 complex, DMSO-acetic anhydride, Hypervalent iodine oxidations: Dess-Martine periodinane, IBX, Iodobenzene diacetate; Oxidations with thalium nitrate, Ag_2O, RuO_4, OSO_4, $NaIO_4$.

Reduction with metal-hydrides of B, Al, Sn, Si. Dissolving metal-reduction, Synthetically useful hydrogenolysis reaction, Sm- and In-based reducing agents and enzymatic reductions.

CEMDSC820P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

(A) Multistep organic synthesis and monitoring of the progress of reaction by thin layer chromatography (TLC).

a. Aniline ⟶ Acetanilide ⟶ 4-Nitroacetanilide ⟶ 4-Nitroaniline

b. Benzophenone ⟶ Benzophenone oxime ⟶ Benzanilide ⟶ Benzoic acid

c. Benzaldehyde ⟶ Benzoin ⟶ Benzil ⟶ Benzilic acid

(B) Estimation of compounds of biological/pharmaceutical importance:

1. Aspirin
2. Paracetamol

CEMDSC821T ADVANCED PHYSICAL CHEMISTRY 2 Credits: 03

Theory **Marks: 50**

All Units carry equal marks

Unit 1: Introduction to Polymer Chemistry

Different schemes for classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers. Concept of Molecular weight of polymers (*Mn*,*Mw*, M_v) Molecular weight distribution and its significance. Determination of molecular weight by end group analysis, viscometry, light scattering and osmotic pressure methods (no derivation; discussion with working equations). Polydispersity index.

Structure of polymer, Structure Property relationships, Concept of Glass transition temperature (T_g) and melting temperature (T_m) and their methods of determination. Degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

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

Unit 2: Kinetics and Application of Polymers

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

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, Phenol formaldehyde resins (Bakelite, Novalac), Conducting Polymers, [polyacetylene, polyaniline, polypyrrole].

Unit 3: Nanomaterials-1

Introduction to Nanoscience, Emergence of Nanoscience with special reference to Feynman and Drexler, Role of particle size, Spatial and temporal scale, Exciton, Concept of confinement, strong and weak confinement with suitable examples, Development of quantum structures, Basic concept of quantum well, quantum wire and quantum dot. Density of states of 1D,2D& 3D structure, surface effect.

Types of Nanomaterials: Synthesis and Uses: Nanoclusters, Solid solutions, Thin film, Nanocomposites (Metal Oxide and Polymer based), Core Shell Nanostructure, Buckyballs,

Carbon nanotubes and, Zeolites minerals, Dendrimers, Micelles, Liposomes, Block Copolymers, Porous Materials, Metal Nanocrystals, Semiconductor nanomaterials, MOF.

Unit 4: Nanomaterials-2

Properties of nanomaterials: Optical, Magnetic, Electronic and mechanical.

Synthesis using Physical Methods: Physical Vapour Deposition (PVD), Arc discharge, DC sputtering, Ion sputtering, Ball Milling, Molecular beam epitaxy, Electro-deposition.

Chemical Methods: Metal nanocrystals by reduction, Sol- gel, Solvothermal synthesis; Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation methods.

Self assembly and Lithography: Self assembly, Process of self assembly, colloids, Introduction to Lithography, E-beam Lithography.

CEMDSC821P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Polymer synthesis

1. Polymerization of Styrene with 2,2'-Azobisisobutyronitrile in Solution
2. Preparation of Polystyrene by an Emulsion Polymerization Process
3. Redox polymerization of acrylamide
4. Preparation of nylon 66/610
5. Preparation of urea-formaldehyde resin /novolac resin.

Polymer characterization:

1. Determination of molecular weight by viscometry:
(a) Polyacrylamide-aq. $NaNO_2$ solution
(b) Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of “head-to-head” monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).

Nanomaterials:

1. Synthesis and study of silver nano particles.

Reference Books:

1. Lee J. D. *Concise Inorganic Chemistry*, 5th Ed., Wiley India Pvt. Ltd., 2008.
2. Douglas, B. E. and McDaniel, D. H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970.
3. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS publications, 1962.
4. Atkins, P. *Shriver & Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press (2010).
5. Cotton, F.A., Wilkinson, G. and Gaus, P. L., *Basic Inorganic Chemistry 3rd Ed*., Wiley India.
6. Sharpe, A. G., *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005.
7. Huheey, J. E.; Keiter, E. A. &Keiter, R.L., *Inorganic Chemistry, Principles of Structure and Radioactivity 4th Ed*., Harper Collins 1993, Pearson, 2006.
8. Atkins, P.W. & Paula, J. *Physical Chemistry*, Oxford Press 2006.
9. Mingos, D.M.P., *Essential trends in Inorganic Chemistry*, Oxford University Press (1998).
10. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
11. Burgess, J., *Ions in solution: basic principles of chemical interactions*, Ellis Horwood (1999).
12. Finar, I. L. Organic Chemistry (Vol- 1), 6th Edition, Pearson Education, 2002
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15. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
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17. Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
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20. Castellan, G. W. Physical Chemistry, Narosa
21. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach,Viva Press
22. Engel, T. & Reid, P. Physical Chemistry, Pearson
23. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
24. Maron, S. &Prutton Physical Chemistry
25. Ball, D. W. Physical Chemistry, Thomson Press
26. Mortimer, R. G. Physical Chemistry, Elsevier
27. Laidler, K. J. Chemical Kinetics, Pearson
28. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry
29. Rakshit, P.C., Physical Chemistry Sarat Book House
30. Zemansky, M. W. &Dittman, R.H. Heat and Thermodynamics, Tata-McGrawHill
31. Rastogi, R. P. &Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas
32. Klotz, I. M. & Rosenberg, R. M. Chemical Thermodynamics, Wiley
33. Bijan K. Paul, Introductory Notes on Quantum Chemistry, Global Net Publication

34. Material Science & Engineering – An Introduction by William D. Callister Jr.
35. Grain growth and control of microstructure and lecture in polycrystalline materials by V. Lu. Novikov & VladimiNovikov
36. Nanoscale Materials- Liz Marzan&Kamat
37. Introduction to Nanotechnology by Charles P. Poole, Jr., Frank J. Owens
38. Handbook of nanoscience, Eng. & Technology by W. Gaddand, D. Bernner, S.L. Solnki& G.J. Infrate (Eds), CRC press 2002
39. Nanoscience& Technology: Novel structure and phenomea by Ping Sheng (Editor)
40. Nano Engineering in Science & Technology: An introduction to the world of nano design by Michael Rieth
41. Processing & properties of structural naonmaterials by Leon L. Shaw (editor)
42. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al. Wiley VCH VerlagGmbh& Co, Weinheim
43. Nanostructure and Nanomaterials: Synthesis, Properties and Application by G. Cao, Imperial College Press, 2004

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1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* 6th Ed., Pearson, 2009
2. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
3. Nad A. K., Mahapatra B. and Ghosal A. An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.
4. Ghosh S., Das Sharma M., Majumder D and Manna S. Chemistry in Laboratory, Santra Publication Pvt Ltd
5. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic
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7. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
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9. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007)
10. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency
11. University Hand Book of Undergraduate Chemistry Experiments, edited by
12. Mukherjee, G. N., University of Calcutta
13. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
14. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.

Part B

Minor Course in Chemistry for 4-year UG Programme (Honours in subjects other than Chemistry) & 3-year Multidisciplinary UG Programme

SEMESTER I

Paper	Course ID	Course Content	Marks	Total Credit
CHEMISTRY 1	**CEMMIN101T/ CEMCOR101T**	Unit-1: Inorganic Chemistry 1 Unit-2: Organic Chemistry 1 Unit-3: Physical Chemistry 1	Theoretical : 50	03
	CEMMIN101P/ CEMCOR101P		Practical : 50	02

SEMESTER II

Paper	Course ID	Course Content	Marks	Total Credit
CHEMISTRY 2	**CEMMIN202T/ CEMCOR202T**	Unit-1:Inorganic Chemistry 2 Unit-2: Organic Chemistry 2 Unit-3: Physical Chemistry 2	Theoretical : 50	03
	CEMMIN202P/ CEMCOR202P		Practical : 50	02

SEMESTER III

Paper	Course ID	Course Content	Marks	Total Credit
CHEMISTRY 3	**CEMMIN303T/ CEMCOR303T**	Unit-1: Inorganic Chemistry 3 Unit-2: Organic Chemistry 3 Unit-3: Physical Chemistry 3	Theoretical: 50	03
	CEMMIN303P/ CEMCOR303P		Practical: 50	02

SEMESTER IV

Paper	Course ID	Course Content	Marks	Total Credit
CHEMISTRY 4	**CEMCOR404T**	Unit-1: Inorganic Chemistry 4 Unit-2: Organic Chemistry 4 Unit-3: Physical Chemistry 4	Theoretical: 50	03
	CEMCOR404P		Practical: 50	02

SEMESTER V

Paper	Course ID	Course Content	Marks	Total Credit
CHEMISTRY 5	**CEMCOR505T**	Unit-1: Inorganic Chemistry 5 Unit-2: Organic Chemistry 5 Unit-3: Physical Chemistry 5	Theoretical: 50	03
	CEMCOR505P		Practical: 50	02

SEMESTER VI

Paper	Course ID	Course Content	Marks	Total Credit
CHEMISTRY 6	**CEMCOR606T**	Unit-1: Inorganic Chemistry 6 Unit-2: Organic Chemistry 6 Unit-3: Physical Chemistry 6	Theoretical: 50	03
	CEMCOR606P		Practical: 50	02

SEMESTER VII

Paper	Course ID	Course Content	Marks	Total Credit
ADVANCED CHEMISTRY 1	**CEMSMC701T**	Unit-1: Inorganic Chemistry 7 Unit-2: Organic Chemistry 7 Unit-3: Physical Chemistry 7	Theoretical: 50	03
	CEMSMC701P		Practical: 50	02

SEMESTER-I

CEMMIN101T/ CEMCOR101T CHEMISTRY 1

Theory (Credits: Theory-03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry1

Atomic Structure

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, Aufbau principle and its limitations.

Chemical Periodicity

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

Acids and bases

Brönsted-Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.

Unit-2: Organic Chemistry 1

Fundamentals of Organic Chemistry

Concept of hybridization, Structure and shape of organic molecules on the basis of VBT.
Electronic displacements: inductive effect, resonance and hyperconjugation; nucleophiles electrophiles; reactive intermediates: carbocations, carbanion.

Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

Alkanes (up to 5 Carbons): Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: mechanism for free radical substitution: halogenation.

Alkenes (up to 5 Carbons): Preparation: elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: *cis*-addition (alkaline $KMnO_4$) and *trans*-addition (bromine) with mechanism, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

Alkynes(up to 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 alkaline $KMnO_4$.

Unit-3: Physical Chemistry 1

Kinetic Theory of Gas and Real gas

Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion; Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

Deviation of gases from ideal behaviour; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features.

Liquids

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

CEMMIN101P/CEMCOR101P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. **Preparation of standard solution:**

   (a) Primary standard: $K_2Cr_2O_7$ and Oxalic acid

   (b) Secondary standard: $KMnO_4$, $Na_2S_2O_3$

   (c) Standardization of secondary standard solution: $KMnO_4$, $Na_2S_2O_3$

2. **(A) Determination of single solid and liquid compounds:**

   (a) Oxalic acid, Resorcinol, Glucose, Salicylic acid, Benzoic acid.

   (b) Ethanol, Acetone, Aniline, Nitrobenzene, Benzaldehyde.

   (B) Preparation:

   (a) Green bromination of acetanilide

   (b) Dibenzalacetone

3. **Determination of**

   (a) Relative viscosity of a solution

   (b) Relative surface tension of a solution

SEMESTER-II

CEMMIN202T/ CEMCOR202T CHEMISTRY 2

Theory (Credits: Theory-03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry 2

Chemical bonding and molecular structure

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

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, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

Redox reactions. Balancing of equations by oxidation number and ion-electron method, oxidimetry and reductimetry.

Unit-2: Organic Chemistry 2

Stereochemistry

Different types of isomerism: geometrical and optical isomerism, concept of chirality and optical activity (up to two carbon atoms), asymmetric carbon atom, elements of symmetry (plane and centre), interconversion of Fischer and Newman representations, enantiomerism and diastereomerism, *meso*compounds, *threo* and *erythro*, D and L, *cis* and *trans* nomenclature, CIP rules, R/S (upto 2 chiral carbon atoms) and *E*/*Z* nomenclature

Nucleophilic substitution and elimination reactions

Nucleophilic substitutions: S_N1 and S_N2 reactions, Eliminations: E1 and E2 reactions (elementary mechanistic aspects), Saytzeff and Hofmann eliminations, elimination, substitution vs elimination.

Unit-3: Physical Chemistry 2

Chemical Energetics

Intensive and extensive variables, state and path functions, isolated, closed and open systems, zeroth law of thermodynamics, concept of heat, work internal energy and statement of first law, enthalpy, H, relation between heat capacities, calculations of q, w, U and H for the reversible, irreversible and free expansion of gases

Standard states, Heats of reaction, enthalpy of formation of molecules and ions and enthalpy of combustion and its applications, laws of thermochemistry, bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchoff's equation, and effect of pressure on enthalpy of reactions

Statement of the second law of thermodynamics, Concept of heat reservoirs and heat engines.

CEMMIN202P/CEMCOR202P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. **Estimation of**
   (a) Fe^{2+} ion in Mohr's salt (permanganometry and dichrometry)
   (b) Cu^{2+} by iodometrically

2. **Analysis of unknown organic compounds:**
   Detection of special elements (N, Cl), Solubility, detection of functional groups (-COOH, -OH (phenolic), carbonyl, $-ArNH_2$, $-ArNO_2$)

3. Determination of solubility product of KHTa

SEMESTER-III

CEMMIN303T/ CEMCOR303T CHEMISTRY 3

Theory (Credits: Theory-03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry 3

Radioactivity

Natural radioactivity, Radioactive decay law, half life, average life, Soddy Fajan's Group displacement law, Nuclear stability and nuclear binding energy, Magic numbers, Nuclear Reactions, Artificial radioactivity, transmutation of elements, fission, fusion and spallation reaction.

Chemical Bonding

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 1st and 2nd periods. (including idea of *s*- *p* mixing)

Unit-2: Organic Chemistry 3

Alcohol and ethers

Properties of Alcohols: Boiling point and Solubility. Synthesis, Concept of Fermentation of Carbohydrates for the formation of alcohols like ehtanol. Reaction of alcohols (mechanism not required): Oxidation to carbonyls and carboxylic acids, Differentiation of 1^0, 2^0 and 3^0 alcohols by Oxidation (Lucas test and using heated Cu at 300 ^{0}C), Wilkinsons' ether synthesis.

Carbonyls

Preparation. Reactions of carbonyl compounds: Benzoin condensation, Cannizzaro, Wittig reaction, Clemmensen reduction, Wolff-Kishner reaction. Concept of tautomerization, Formation of enols and enolates, Alkylation, Identification of aldehyde using Tollen's and Fehling's solution, Mannich reaction, Perkin reaction, Favorskii rearrangement.
Nucleophilic addition to α,β-unsaturated carbonyl system: general principle of direct and conjugate addition, Michael addition, Robinson annulation.

Unit-3: Physical Chemistry 3

Chemical Kinetics

Introduction of rate law, Order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions

Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)

CEMMIN303P/CEMCOR303P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. Estimation Na_2CO_3-$NaHCO_3$ mixture using anhydrous Na_2CO_3 as primary standard
2. Estimation of oxalate- oxalic acid mixture using $KMnO_4$ as titrant
3. Estimation of aniline
4. Hydrolysis of benzamide to benzoic acid
5. Determination of heat of solution of Strong acid (HCl) and strong base (NaOH)
6. Determination of heat of solution of Weak acid (AcOH) and strong base (NaOH)

SEMESTER-IV

CEMCOR404T CHEMISTRY 4

Theory (Credits: Theory-03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry 4

Comparative study of p-block elements:
Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements:

i) B-Al-Ga-InTl
ii) C-Si-Ge-Sn-Pb
iii) N-P-As-Sb-Bi
iv) O-S-Se-Te
v) F-Cl-Br-I

Unit-2: Organic Chemistry 4

Carboxylic acids and their derivatives: General methods of synthesis of carboxylic acids. Preparation of Acyl halides, Esters, Anhydrides and Amides from Carboxylic acids. Hydrolysis of esters (BAc2, AAc2 with mechanism) and amides.

Synthetic use of DEM and EAA: alkylation and preparation of simple cyclic compounds.

Nitro compounds (aliphatic and aromatic): Reduction under different conditions; Nef carbonyl synthesis.

Amines (Aliphatic & Aromatic): preparation, separation (Hinsberg's method) and identification of primary, secondary and tertiary amines; reaction (with mechanism): diazotization and diazo coupling reaction, Diazonium salts and their related compounds: reactions (with mechanism) involving replacement and retention of nitrogen;

Alkylnitrile and isonitrile: Reduction and hydrolysis

Unit-3: Physical Chemistry 4

Chemical Equilibrium: Thermodynamic conditions for equilibrium, degree of advancement; Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of K_P, K_C and K_X and relation among them; van't Hoff reaction isotherm, isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle.

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water; Ionization of weak acids and bases, pH scale, common ion effect; Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts; Buffer solutions; Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

CEMCOR404P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. Paper chromatographic separation of Ni^{2+}, Co^{2+}
2. To find the total hardness of water by EDTA titration
3. Estimation of vitamin C
4. Preparation of acetanilide from aniline
5. Determination of solubility/ solubility product of KHTa.
6. Preparation of sodium acetate/acetic acid buffer solutions.

SEMESTER-V

CEMCOR505T CHEMISTRY 5

Theory (Credits: Theory-03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry 5

Coordination Chemistry

Coordinate bonding: double and complex salts. Werner's theory of coordination complexes, Classification of ligands, Ambidentate ligands, chelates (inner metallic complexes, 1^{st} and 2^{nd} order) Coordination numbers, IUPAC nomenclature of coordination complexes (upto two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, Geometrical isomerism in square planar and octahedral complexes

Elementary Crystal Field Theory: splitting of d^nconfigurations in octahedral and tetrahedral fields

Unit-2: Organic Chemistry 5

Heterocycles: 5- and 6-membered rings with one heteroatom; reactivity, orientation and important reactions of furan, pyrrole, thiophene and pyridine; synthesis of pyrrole: Knorr synthesis, Paal-Knorr synthesis, Hantzsch synthesis; furan: Paal-Knorr synthesis, Feist-Benary synthesis; thiophenes: Paal-Knorr synthesis, Hinsberg synthesis; pyridine: Hantzsch synthesis. Reactions: electrophilic and nucleophilic substitution reactions (Vilsmeier- Haack, Friedel Crafts, Mannich, Nitration, Chichibabin).

Organometallics: Preparation and synthetic uses of Organomagnesium and organolithium compounds: Grignard's reagent, preparation of alcohols, carboxylic acids, aldehydes and ketones, comparison of reactivity between GR and organolithium compounds.

Unit-3: Physical Chemistry 5

Conductance

Conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Ostwald's dilution law. Concept of Transport number.

Electrochemistry

Reversible Chemical cells with examples; Electromotive force of a cell and its measurement.

Nernst equation; Standard electrode (reduction) potential; Electrochemical series; Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data, liquid junction potential; pH determination using hydrogen electrode; Qualitative discussion of potentiometric titrations. (redox, precipitation).

CEMCOR505P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$.solution.
2. Estimation of Fe(III) and $Cr_2O_7^{2-}$ in a mixture using $K_2Cr_2O_7$
3. Thin Layer Chromatography (mixture of amino acids)
4. Nitration of aromatic compounds (cold condition)
5. Perform the following conductometric titrations (any one):
   (i) Strong acid vs. strong base
   (ii) Weak acid vs. strong base
6. pH metric titration of acetic acid with sodium hydroxide.

SEMESTER-VI

CEMCOR606T CHEMISTRY 6

Theory (Credits: Theory-03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry 6

Bioinorganic Chemistry

Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}) Toxic metal ions and their effects, chelation therapy, Pt and Au complexes as drugs, metal dependent diseases

Unit-2: Organic Chemistry 6

Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): mutarotation; epimerization; reactions: osazone formation, bromine-water oxidation, HNO_3 oxidation, reduction to alditols, stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's &Wohl's methods) of aldoses;

Disaccharides: Glycosidic linkages, structure of sucrose, inversion of cane sugar.

Amino acids: Synthesis Strecker, Gabriel, isoelectric point, isoionic point, zwitterions; electrophoresis, reaction: ninhydrin reaction,

Peptides and Proteins: Peptide linkage and its geometry; syntheses of dipeptides using **N**-protection & C-protection, hydrolysis; Fibrous protein and Globular proteins, Denaturation.

Structure of Nucleic acids: Nucleosides and Nucleotides corresponding to DNA and RNA. Base pairing: Hydrogen bonding.

Synthesis and therapeutic uses of paracetamol, ibuprofen and aspirin

Unit-3: Physical Chemistry 6

Polymer classification and nomenclature, Molecular forces and chemical bonding in polymers. Different types of Molecular weight. Distribution and its significance. Polydispersity index. Molecular weight determination by end group analysis, viscometry, and osmotic pressure methods.

Types of polymerization processes and kinetics. Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional and Poly-functional systems. Introduction to Structure Property relationship

CEMCOR606P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

Qualitative Analysis of Inorganic Samples using Dry tests, Wet tests and special tests with HCl, HNO_3 and NaOH extracts. The sample should contain **three radicals** and must be **water soluble and/or HCl soluble.**

Cation Radicals: Na^+, K^+, Ca^+, Sr^+, Ba^{2+}, Mn^{2+}/Mn^{4+}, Fe^{3+},, Ni^{2+}, Cu^{2+}, Zn^{2+}

Anion Radicals: Cl^-, Br^{--}, I^-, S^{2-}, SO_4^{2-}, SO_3^{2-}, NO_3^-, NO_2^-

(The interfering acid radicals and insoluble compounds are not included. Probable composition not required)

Separation of two organic compounds (solid) on the basis of solubility and determination of melting points

Preparation of urea-formaldehyde resin

Preparation of nylon 66/6

SEMESTER-VII

CEMSMC701T ADVANCED CHEMISTRY 1

Theory (Credits: 03) Marks: 50

All Units carry equal marks

Unit-1: Inorganic Chemistry 7

Redox reactions

Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators.

Coordination Chemistry

Coordinate bonding: double and complex salts. Werner's theory of coordination complexes, Classification of ligands, Ambidentate ligands, chelates (inner metallic complexes, 1^{st} and 2^{nd} order) Coordination numbers, IUPAC nomenclature of coordination complexes (upto two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, Geometrical isomerism in square planar.

Unit-2: Organic Chemistry 7

Green Chemistry: Introduction to Green chemistry, Definition, Needs and Goals. Twelve principles: Explanations with examples, Special emphasis on Prevention of waste, Maximum incorporation of starting materials and concept of 'Atom economy' with suitable examples and its calculation, Use of less hazardous chemicals, Catalysis.

Green solvents and Solvent less synthesis: Water, super critical fluids, PEG and basic ides of ionic liquids with few examples. Introduction to solvent less synthesis.

Alternative source of energy: Basic idea of using MAOS technique and use of Ultrasound

Examples of some green synthesis in comparison with standard protocol: Synthesis of catechol, adipic acid and disodium imino diacetate.

Unit-3: Physical Chemistry 7

Electrochemistry

Conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Ostwald's dilution law. Concept of Transport number.

Reversible Chemical cells with examples: Electromotive force of a cell and its measurement. Nernst equation; Standard electrode (reduction) potential; Electrochemical series; Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data, liquid junction potential; pH determination using hydrogen electrode; Qualitative discussion of potentiometric titrations (redox, precipitation).

CEMSMC701P Practical Credits: 02

(60 Lectures/Contact hours) **Marks: 50**

1. Qualitative Analysis of Inorganic Samples using Dry tests, Wet tests and special tests with HCl, HNO_3 and NaOH extracts. The sample should contain **three radicals** and must be **water soluble and/or HCl soluble.**

   Cation Radicals: Na^+, K^+, Ca^+, Sr^+, Ba^{2+}, Mn^{2+}/Mn^{4+}, Fe^{3+},, Ni^{2+}, Cu^{2+}, Zn^{2+}
   Anion Radicals: Cl^-, Br^{--}, I^-, S^{2-}, SO_4^{2-}, SO_3^{2-}, NO_3^-, NO_2^-
   (The interfering acid radicals and insoluble compounds are not included. Probable composition not required)

2. Preparation of benzilic acid from benzil following Green methodology
3. Hydrolysis of methyl salicylate to salicylic acid
4. Conductometric titration of Strong acid (HCl) and Strong Base (NaOH).
5. Potentiometric titrations of Mohr's Salt with potassium dichromate in H_2SO_4.

Reference books (Theory) :

1. Poddar S. N. General and Inorganic Chemistry, Book Syndicate Pvt. Ltd.
2. Dutta R. L. & De G.S. Inorganic Chemistry (Vol I), The New Book Stall.
3. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Wiley India Pvt. Ltd., 2008.
4. Sen Gupta, S. Organic Chemistry, Oxford University Press.
5. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
6. Sen Gupta, S. Basic Stereochemistry of Organic molecules, Oxford University Press.
7. Rakshit P. C. Physical Chemistry, Sarat Book House.
8. Palit S. R. Elementary Physical Chemistry, Science Book Agency.
9. Pahari, S., Physical Chemistry New Central Book Agency.
10. Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry, Kalyani Publishers.

Reference books (Practical):

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* 6th Ed., Pearson, 2009
2. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
3. Nad A. K., Mahapatra B. and Ghosal A. An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.
4. Ghosh S., Das Sharma M., Majumder D and Manna S. Chemistry in Laboratory, Santra Publication Pvt Ltd
5. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic
6. Analysis, CBS Publishers and Distributors.
7. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
8. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
9. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007)
10. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency
11. University Hand Book of Undergraduate Chemistry Experiments, edited by
12. Mukherjee, G. N., University of Calcutta
13. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
14. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.

Part C

Skill Enhancement Course in Chemistry

SE-1– CEMHSE101M/CEMHSE201M/CEMHSE301M/CEMGSE301M/CEMGSE501M

BASIC ANALYTICAL CHEMISTRY
(Credits: Theory-03)

Theory **Marks: 50**

Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results from the point of view of significant figures.

Analysis of soil

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

1. Determination of pH of soil samples.
2. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

1. Determination of pH, acidity and alkalinity of a water sample.
2. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products

Nutritional value of foods, idea about food processing and food preservations and adulteration.

1. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
2. Analysis of preservatives and colouring matter.

Chromatography

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

1. Paper chromatographic separation of mixture of metal ion (Fe3+ and Al3+).
2. To compare paint samples by TLC method.

Ion-exchange

Column, ion-exchange chromatography etc. Determination of ionexchange capacity of anion/ cation exchange resin (using batch procedure if use of column is not feasible).

Analysis of cosmetics

Major and minor constituents and their function

1. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
2. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration

Suggested Applications (Any one)

1. To study the use of phenolphthalein in trap cases.
2. To analyze arson accelerants.
3. To carry out analysis of gasoline.

Suggested Instrumental demonstrations

1. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
2. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

3. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks

Reference Books

1. Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6th
4. Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994).
5. Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016.
6. Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004.
7. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992.
8. Freifelder, D.M. Physical Biochemistry 2nd Ed., W.H. Freeman & Co., N.Y. USA (1982).
9. Cooper, T.G. The Tools of Biochemistry, John Wiley & Sons, N.Y. USA. 16 (1977).
10. Vogel, A. I. Vogel‟s Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996.
11. Mendham, J., A. I. Vogel‟s Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
12. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).
13. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

SE-2– CEMGSE402M/CEMGSE602M

ANALYTICAL and CLINICAL BIOCHEMISTRY
(Credits: Theory-03)

Theory: **Marks: 50**

Review of Concepts from Core Course

Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.
Isolation and characterization of polysachharides.
Proteins: Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins.
Enzymes: Nomenclature, Characteristics (mention of Ribozymes), and Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry.
Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.
Lipoproteins: Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.
Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy. *Enzymes:* Nomenclature, classification, effect of pH, temperature on enzyme activity, enzyme inhibition.

Biochemistry of disease: A diagnostic approach by blood/ urine analysis.

Blood: Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.
Urine: Collection and preservation of samples. Formation of urine. Composition and estimation of constituents of normal and pathological urine.

Reference Books

1. Cooper, T.G. Tool of Biochemistry. Wiley-Blackwell (1977).
2. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: Practical Clinical Biochemistry, Heinemann, London (1980).
4. Devlin, T.M., Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons, 2010.
5. Berg, J.M., Tymoczko, J.L. &Stryer, L. Biochemistry, W.H. Freeman, 2002.
6. Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H. Freeman, 2013.
8. O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods, D. Van Nostrand & Co., 1961.

Part D

Multidisciplinary Course (MDC) in Chemistry

(This course refers to the "MDC" course in Tables 1, 1A and 2 corresponding to structure of the 4-year UG programme (Honours) and 3-year UG programme. This course can only be selected for study by students who have not studied Chemistry at the higher secondary level)

CEMHMD101M/CEMHMD201M/CEMHMD301M/CEMGMD401M/CEMGMD501M/CEMGMD601M

(Credits: Theory-03) **Marks: 50**

BASIC CONCEPTS OF CHEMISTRY

Importance of Chemistry, Nature of matter, States of matter, solids, liquids, gases, classification of matter: mixture, pure substance; Properties of matter and their measurement: Mass, weight, volume, density and temperature. Uncertainty in measurement: precision and accuracy. Laws of chemical combinations: Law of conservation of mass, law of definite proportions, law of multiple proportions, Avogadro's law, Dalton's atomic theory, Atomic and molecular masses, Mole concept and molar mass, percentage composition, Empirical formula and molecular formula, Stoichiometry and stoichiometric calculations, Molarity, mole fraction and molality

STRUCTURE OF ATOM

Discovery of sub-atomic particles: electrons, proton, Rutherford's nuclear model of atom and its' drawbacks, atomic number, mass number, Isobars and isotopes, Bohr's model for hydrogen atom

THERMODYNAMICS

The system and the surroundings, types of systems, state of the system, heat, work, internal energy, First law of thermodynamics.

CHEMICAL EQUILIBRIUM

Law of mass action, idea of chemical equilibrium, Le Chatelier's principle, its applications

ORGANIC COMPOUNDS

Introduction to haloalkanes, Methods of preparation of haloalkanes; Introduction to alcohols, phenols and ethers with suitable examples, their preparation (Reaction mechanisms not required); Introduction to aldehydes, ketones and carboxylic acids with suitable examples, their preparations.

ACIDS, BASES AND BUFFER

Introduction to acids and bases, Arrhenius and Lewis concepts, neutralization reactions, acid-base titration

References

1. NCERT Class XI and XII textbooks in chemistry
2. ISC Class XI and XII textbooks in chemistry