Department of Chemistry

Syllabus Module: CBCS

Semester	Course code – CEM-G	Unit	Sub unit	No. of lectures
Sem - I	CC1/GE 1	**Kinetic Theory of Gases and Real gases**	Concept of pressure and temperature; Collision of gas molecules; Collision number and mean free path. 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 Deviation of real gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states.	4
		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)	2
		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 halfhalf-life and differential method. Temperature dependence of rate constant; Arrhenius equation, energy of activation;	5

		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.	4
		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.	5
		Acids and bases	Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and leveling 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.	4
		Fundamentals of Organic Chemistry	*Electronic displacements*: inductive effect, resonance and hyperconjugation; nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals.	3
		Stereochemistry	Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; 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* (only	8

			one 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.	3
	CC1/GE 1 (PR)		1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. 2. Estimation of oxalic acid by titrating it with $KMnO_4$. 3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$. 4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator. 5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$. 6.Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution.	40
Semester- II	Paper	Unit	Sub unit	No. of lectures
	GE-2	**Chemical Thermodynamics:**	Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy	1

			statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, ΔU and ΔH for reversible, irreversible and free expansion of gases.	2
			Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry, Kirchhoff's equations.	1
			Statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Entropy change of systems and surroundings for various processes and transformations; Auxiliary state functions (G and A) and Criteria for spontaneity and equilibrium.	3
		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;	2
			van't Hoff's reaction isotherm, isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle	1
		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	3

			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	1
		Error Analysis and Computer Applications	*Error analysis***:** accuracy and precision of quantitative analysis, determinate, indeterminate, systematic and random errors; methods of least squares and standard deviations. *Computer applications:* general introduction to computers, different components of a computer; hardware and software; input and output devices; binary numbers and arithmetic; Introduction to computer languages.	3
		Solutions	Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions; Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions; Distillation of solutions; Lever rule; Azeotropes Nernst distribution law and its applications, solvent extraction	2
		Phase Equilibria	Phases, components and degrees of freedom of a system, criteria of phase equilibrium; Gibbs Phase Rule; Derivation of Clausius – Clapeyron equation and its importance in phase equilibria; Phase diagrams of one-component systems (water and CO_2)	2
		Solids	Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law;	2

		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. *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:* addition of bromine, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis. *Alkynes:* (up to 5 Carbons). *Preparation:* acetylene from CaC_2; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides.	3
	GE-2	Practical	Experiment 1: Study of kinetics of acid-catalyzed hydrolysis of methyl acetate Experiment 2: Study of kinetics of decomposition of H_2O_2 (Clock Reaction) Experiment 3: Study of viscosity of unknown liquid (glycerol, sugar) with respect to water. Experiment 4: Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator) Experiment 5:Preparation of buffer solutions and find the pH of an unknown buffer solution by colour matching method	24

			Experiment 6: Determination of surface tension of a liquid using Stalagmometer	
Semester- III	Paper	Unit	Sub unit	No. of lectures
	GE-3	**Chemical Bonding and Molecular Structure**	*Ionic Bonding:* General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.	8
			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.	3
			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) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.	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	5

			elements: i) B-Al-Ga-In-Tl ii) C-Si-Ge-Sn-Pb iii) N-P-As-Sb-Bi iv) O-S-Se-Te v) F-Cl-Br-I	
		Transition Elements (3*d* series)	General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.	4
			Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).	2
		Coordination Chemistry	Werner's coordination theory, Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature	5
		ELECTROCHEMISTRY	**1) 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	4

			salts – applications of solubility product principle	
			2) 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; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations (acid-base) Transport Number and principles Moving-boundary method	4
		Electromotive force	Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry; Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential; Electrochemical series; Concentration cells with and without transference, liquid junction potential; pH Determination using hydrogen electrode and quinhydrone; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)	5
		Aromatic Hydrocarbons	*Benzene: Preparation*: from phenol, by decarboxylation, from acetylene. *Reactions*: electrophilic substitution reaction (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination),	2

			and Friedel-Crafts reaction (alkylation and acylation) (up to 4 carbons on benzene).	
		Organometallic Compounds	Introduction; *Grignard reagents*: *Preparations* (from alkyl and aryl halide); Reformatsky reaction.	1
		Aryl Halides	*Preparation:* (chloro- and bromobenzene): from phenol, Sandmeyer reactionand effect of nitro substituent (activated nucleophilic substitution	1
	GE-3 (PR)	**Qualitative semimicro analysis of mixtures containing two radicals.**	Cation Radicals: Na^{+},K^{+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Al^{3+}, Cr^{3+}, Mn^{2+}/Mn^{4+}, Fe^{3+}, Co^{2+}/Co^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Sn^{2+}/Sn^{4+}, NH^{4+}, Anion Radicals: F^{-}, Cl^{-}, Br^{-}, BrO_3^{-}, I^{-}, IO_3^{-}, SCN^{-}, S^{2-}, SO_4^{2-}, NO_3^{-}, NO_2^{-}, PO_4^{3-}, AsO_4^{3-}, BO_3^{3-}, CrO_4^{2-} / $Cr_2O_7^{2-}$	40
Semester- IV	Paper	Unit	Sub unit	No. of lectures
	GE-4	**Alcohols, Phenols and Ethers**	*Alcohols:* (up to 5 Carbons). *Preparation:* 1°-, 2°- and 3°- alcohols: using Grignard reagent, reduction of aldehydes, ketones, carboxylic acid and esters; *Reactions:* With sodium, oxidation (alkaline $KMnO_4$, acidic dichromate). *Diols:* Pinacol- pinacolone rearrangement (with mechanism) (*with symmetrical diols* only).	3
			Phenols: Preparation: cumene hydroperoxide method, from diazonium salts; acidic nature of phenols; *Reactions:* electrophilic	2

			substitution: nitration and halogenations; Reimer –Tiemann reaction, Schotten – Baumann reaction, Fries rearrangementand Claisen rearrangement. *Ethers: Preparation:* Williamson's ether synthesis; *Reaction*: cleavage of ethers with HI.	
		Carbonyl Compounds	*Aldehydes and Ketones (aliphatic and aromatic):* (Formaldehye, acetaldehyde, acetone and benzaldehyde): *Preparation:* from acid chlorides, from nitriles and from Grignard reagents; general properties of aldehydes and ketones; *Reactions:* with HCN, $NaHSO_3$, NH_2-G derivatives and with Tollens' and Fehling's reagents; iodoform test; aldol condensation (with mechanism); Cannizzaro reaction (with mechanism), Wittig reaction, benzoin condensation; Clemmensen reduction, Wolff- Kishner reduction	5
		Quantum Chemistry & Spectroscopy	Spectroscopy and its importance in chemistry. Wave-particle duality. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction with matter. Types of spectroscopy. Difference between atomic and molecular spectra Postulates of quantum mechanics, quantum mechanical operators. Free particle. Particle in a 1-D box (complete solution), quantization, normalization of wave functions, concept of zero-point energy. *Rotational Motion:* Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization	8

			of rotational energy levels. Microwave (pure rotational) spectra of diatomic molecules. Selection rules. Structural information derived from rotational spectroscopy. *Vibrational Motion:* Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels. Selection rules, IR spectra of diatomic molecules.	
		Carboxylic Acids and Their Derivatives	*Carboxylic acids* (aliphatic and aromatic): strength of organic acids: comparative study with emphasis on factors affecting pK values; *Preparation:* acidic and alkaline hydrolysis of esters ($B_{Ac}2$ and $A_{AC}2$ mechanisms only) and from Grignard reagents. *Carboxylic acid derivatives (*aliphatic*):* (up to 5 carbons). *Preparation:* acid chlorides, anhydrides, esters and amides from acids; *Reactions:* Interconversion among acid derivatives. *Reactions:*Claisen condensation; Perkin reaction.	2
		Amines and Diazonium Salts	*Amines (aliphatic and aromatic):* strength of organic bases; *Preparation*: from alkyl halides, Hofmann degradation; *Reactions:* with HNO_2 (distinction of 1°-, 2°- and 3°- amines), Schotten – Baumann reaction , Diazo coupling reaction (with mechanism). *Diazonium salts: Preparation:* from aromatic amines; *Reactions:* conversion to benzene, phenol, benzoic acid and nitrobenzene.	3

			Nitro compounds (aromatic): reduction under different conditions (acidic, neutral and alkaline).	1
		Amino Acids	*Amino Acids: Preparations* (glycine and alanine only)*:* Strecker synthesis, Gabriel's phthalimide synthesis; general properties; zwitterion, isoelectric point.	2
		Carbohydrates	*Carbohydrates:* classificationand general properties; glucose and fructose: constitution; osazoneformation; oxidation-reduction reactions; ascending (Kiliani –Fischer method) and descending (Ruff's method) in monosaccharides (aldoses only); mutarotation	4
		Crystal Field Theory	Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination	4
	GE-4 (PR)	**1.Qualitative Analysis of Single Solid Organic Compound(s)**	Experiment A: Detection of special elements (N, Cl, and S) in organic compounds. Experiment B: Solubility and Classification (solvents: H_2O, dil. HCl, dil. NaOH) Experiment C: Detection of functional groups: Aromatic-NO_2, Aromatic -NH_2, -COOH, carbonyl (no distinction of –CHO and >C=O needed), -OH (phenolic) in solid organic compounds. Experiments A - C with unknown (at least 6) solid samples containing not more than two of the	40

			above type of functional groups should be done.	
		2.Identification of a pure organic compound	*Solid compounds*: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid. *Liquid Compounds*:methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene	