CHEMISTRY

1. Some basic concepts in Chemistry

Importance of Chemistry, physical quantities and their measurement in Chemistry, SI Units, uncertainty in measurements and use of significant figures, Unit and dimensional analysis, Matter and its nature, laws of chemical combinations, atomic, and molecular, masses mole concept, molar masses, percentage composition and molecular formula, chemical stoichiometry.

2. States of matter

Three states of matter, gaseous state, gas laws (Boyle's Law and Charles Law), Avogadro's Law, Grahams'Law of diffusion, Dalton's law of partial pressure, ideal gas equation, Kinetic theory of gases, real gases and deviation from ideal behaviour, van der Waals' equation, liquefaction of gases and critical points, Intermolecular forces; liquids and solids.

3. Atomic structure

Earlier atomic models (Thomson's and Rutherford) , emission spectrum of hydrogen atom, Bohr's model, of hydrogen atom, Limitations of Bohr's model, dual nature of matter and radiation, Heisenberg uncertainty principle, quantum mechanical model of atom (quantum designation of atomic orbitals and electron energy in terms of principal, angular momentum and magnetic quantum numbers), electronic spin and spin quantum numbers, Pauli's exclusion principle, general idea of screening (constants) of outer electrons by inner electrons in an atom, *Aufbau* principle, Hund's rule, atomic orbitals and their pictorial representation, electronic configurations of elements.

4. Classification of elements and periodicity in properties

Need and genesis of classification of elements (from Doebereiner to Mendeleev), Modern periodic law and present form of periodic table, Nomenclature of elements with atomic number > 100, electronic configurations of elements and periodic table, electronic configuration and types of elements and s, p, d and f blocks, periodic trends in properties of elements (atomic size, ionization enthalpy, electron gain enthalpy, valence/ oxidation states and chemical reactivity).

5. Chemical energetics

Some basic concepts in thermodynamics, first law of thermodynamics, heat capacity, measurement of ΔU and ΔH, calorimetry, standard enthalpy changes, thermochemical equations, enthalpy changes during phase transformations, Hess's Law, standard enthalpies of formation, bond enthalpies and calculations based on them.

6. Chemical bonding

Kossel -Lewis approach to chemical bond formation, ionic bonds, covalent bonds, polarity of bonds and concept of electronegativity, valence shell electron pair repulsion (VSEPR) theory , shapes of simple molecules, valence bond theory, hybridization involving s, p and d orbitals and shapes of molecules σ and π bonds; Molecular orbital theory involving homounclear diatomic molecules; Hydrogen-bonding.

7. Equilibrium

Equilibrium in physical and chemical processes

Equilibrium in physical and chemical processes, dynamic equilibrium, law of chemical equilibrium and equilibrium constant, homogeneous equilibrium, heterogenous equilibrium, application of equilibrium constants, Relationship between reaction quotient Q, equilibrium constant, K and Gibbs' energy G; factors affecting equilibrium-Le Chateliar's principle.

Ionic equilibrium

Acids, Bases and Salts and their ionization, weak and strong electrolytes degree of ionization and ionization constants, concept of pH, ionic product of water, buffer solution, common ion effect, solubility of sparingly soluble salts and solubility products.

8. Redox reactions

Electronic concepts of reduction - oxidation, redox reactions, oxidation number, balancing of redox reactions.

9. Solid state Chemistry

Classification of solids based on different binding forces: molecular, ionic, covalent and metallic solids, amorphous and crystalline solids; unit cells in two dimensional and three dimensional lattices, calculation of density of a unit cell, packing in solids, voids, number of atoms per unit cell in a cubic unit cell, point defects, electrical and magnetic properties.

10. Chemical thermodynamics

Spontaneous processes, energy and spontaneity , entropy and second law of thermodynamics, concept of absolute entropy, Gibbs energy and spontaneity, Gibbs energy change and equilibrium constant.

11. Solutions

Types of solutions, different units for expressing concentration of solution, mole fraction, percentage (by volume and mass both), definitions of dilute solutions, vapour pressure of solutions and Raoult's Law, Colligative properties, lowering of vapour pressure, depression of freezing point, elevation of boiling points and osmotic pressure, determination of molecular masses using colligative properties, abnormal values of molecular masses, van't Hoff factor. simple numerical problems.

12. Chemical kinetics

Rate of chemical reactions, factors, affecting rates of reactions – concentration, temperature and catalyst, order and molecularity of reactions, rate law and rate constant, differential and integral forms of first order reaction, half-life (only zero and first order) characteristics of first order reaction, effect of temperature on reactions, Arrhenius theory - activation energy, collision theory of reaction rate (no derivation).

13. Electrochemistry

Conductance in electrolytic solutions, specific and molar conductivity, variation of conductivity with concentration, Kohlrausch's law, electrolysis and laws of electrolysis (elementary idea), electrolytic and galvanic cells, emf. of a cell, standard electrode potential, Nernst equation, concentration cell, fuel cells, cell potential and Gibbs energy, dry cell and lead accumulator.

14. Surface chemistry

Adsorption - physisorption and chemisorption, factors affecting adsorption of gases on solids, catalysis, homogeneous and heterogeneous activity and selectivity, enzyme catalysis, colloidal state, distinction between true solutions, colloids and suspensions; lyophillic, lyophobic, multimolecular and macromolecular colloids, properties of colloids, Tyndal effect, Brownian movement, electrophoresis, coagulation, emulsions - type of emulsions.

15. Hydrogen

Position of hydrogen in periodic table, isotopes of hydrogen, heavy water, hydrogen peroxide-preparation, reactions and structures; hydrides and their classification.

16. s-Block Elements (Alkali and Alkaline Earth metals):

Group 1 and Group 2 elements

Electronic configurations and general trends in physical and chemical properties, anomalous properties of the first element of each group, diagonal relationship.

Preparation and properties of some important compounds, sodium

carbonate, sodium hydroxide, sodium hydrogen carbonate and industrial uses of lime and limestone, biological significance of Na, K, Mg and Ca.

17. General principles and processes of isolation of elements

Principles and methods of extraction - concentration, reduction, (chemical and electrolytic methods), and refining.

Occurrence and principles of extraction of Al, Cu, Zn and Fe.

1 8. p-Block Elements

Introduction to p-block elements

Electronic configurations and general trends in properties, viz. atomic sizes, ionization enthalpies, electronegativity values, electron gain enthalpies and oxidation states across the periods and down the groups in the p-block.

Unique behaviour of the top element in each group of the block - the covalency limit and the p_π - p_π overlap in some molecules (e.g. N_2, O_2) and its consequences; general trend in catenation tendency down each group.

Group-wise study of the p-block Elements

Group 13 - In addition to the general characteristics as outlined above, properties and uses of aluminium, nature of hydrides/ halides and oxides; Properties, structures and uses of diborane boron halides, aluminium chloride, borax, boric acid and alums.

Group 14 - In addition to the general characteristics; carbon – catenation, allotropic forms (diamond and graphite), properties and structures of oxides; silicon - silicon tetrachloride, and structures and uses of silicates, silicones and zeolites.

Group 15 - In addition to the general characteristics, the general trends in the nature and structures of hydrides, halides and oxides of these elements. Preparation and properties of ammonia, nitric acid, phosphine and halides of phosphorus, structures of the oxoacids of phosphorus.

Group 16 - In addition to the general characteristics, preparations, properties and uses of dioxygen, simple oxides, ozone; sulphur - allotropic forms, compounds of sulphur, preparation, properties and uses of sulphur dioxide and sulphuric acid, industrial preparations of sulphuric acid, structures of oxoacids of sulphur.

Group 17 - In addition to the general characteristics, occurrence, trends in physical and chemical properties, oxides and oxoacids of halogens (structures only), preparation, properties and uses of chlorine and hydrochloric acid, trends in the acidic nature of hydrogen halides. Interhalogen compounds (structures only).

Group 18 - General introduction, electronic configurations, occurrence, trends in physical and chemical properties and uses, - fluorides and oxides of xenon (structures only).

19. The d-and f-Block elements

General introduction, electronic configuration, occurrence and characteristics of transition metals, general trends in properties of the first row transition metals –physical properties, ionization enthalpy, oxidation states, ionic radii, colour, catalytic property, magnetic property, interstitial compounds, alloy formation; preparations and properties of $K_2Cr_2O_7$ and $KMnO_4$.

Lanthanoids - Electronic configuration and oxidation states, chemical reactivity and lanthanoid contraction.

Actinoids - Electronic configuration and oxidation states.

20. Coordination compounds

Introduction to ligands, coordination number, colour, magnetic properties, and shapes; IUPAC - nomenclature of mononuclear coordination compounds, isomerism , bonding-valence bond approach to the bonding and basic ideas of Crystal Field Theory, colour and magnetic properties. Elementary ideas of metal - carbon bonds and organometallic compounds, importance of co-ordination compounds (in qualitative analysis, extraction of metals and biological systems).

21. Some basic principles of Organic Chemistry

- Tetravalence of carbon, hybridization (s and p), shapes of simple molecules, functional groups:-C=C-, -C≡C- and those containing halogens, oxygen, nitrogen and sulphur; homologous series, isomerism.

- General introduction to naming organic compounds-trivial names and IUPAC nomenclature.

- Electronic displacement in a covalent bond; inductive effect, electromeric effect, resonance and hyperconjugation. Fission of covalent bond: free radicals, electrophiles and nucleophiles, carbocations and carbonanions.

- Common types of organic reactions: substitution, addition, elimination and rearrangement reactions.

22. Hydrocarbons

Alkanes and cycloalkanes : classification of hydrocarbons, alkanes and cycloalkanes, nomenclature and conformations of alkanes and cycloalkanes.

Alkenes and alkynes : Nomenclature and isomerism, general methods of preparation, properties (physical and chemical), mechanism of electrophilic

addition, Markownikoff's rule, peroxide effect, acidic character of alkynes, polymerisation reactions.

Aromatic hydrocarbons: Benzene and its homologues, nomenclature, sources of aromatic hydrocarbons (coal and petroleum), structure of benzene, chemical reaction of benzene-mechanism of electrophilic substitution. Directive influence of substituents and their effect on reactivity.

Petroleum and petrochemicals : Composition of crude oil fractionation and uses, quality of gasoline, LPG, CNG, cracking and reforming, petrochemicals.

23. Purification and characterization of carbon compounds

- Purification of carbon compounds : filtration, crystallisation, sublimation, distillation chromatography,
- Qualitative analysis : detection of nitrogen, sulphur, phosphorus and halogens.
- Quantitative analysis : estimation of different elements (H, N, halogens, S and P)
- Determination of molecular masses : Silver salt method, chloroplatinate salt method, calculations of empirical and molecular formulas.

24. Organic compounds with functional groups containing halogens (X)

- Nature of C-X bond in haloalkanes and haloarenes, nomenclature, physical and chemical properties, mechanism of substitution reactions, reactivity of C-X bond in haloalkanes and haloarenes.
- Some commercially important compounds : dichloro, trichloro and tetrachloromethanes; p-dichlorobenzene, freons, BHC, DDT, their uses and important reactions.

25. Organic compounds with functional groups containing oxygen

Alcohols and phenols : Nomenclature, methods of preparation, physical and chemical properties; chemical reactivity of phenols in electrophilic substitutions, acidic nature of phenol, ethers: electronic structure, structure of functional group, nomenclature, important methods of preparation, physical and chemical properties, some commercially important compounds.

Aldehydes and ketones : Electronic structure of carbonyl group, nomenclature, important methods of preparation, physical properties and chemical reactions, relative reactivity of aldehydic and ketonic groups, acidity of α-hydrogen, aldol condensation. Connizzarro reaction, nucleophilic addition reaction to >C=O groups.

Carboxylic acids : Electronic structure of-COOH, Nomenclature, important methods of preparation, physical properties and effect of substituents on α-carbon on acid strength, chemical reactions.

Derivatives of carboxylic acids : Electronic structure of acid chloride, acid anhydride, ester and amide groups, nomenclature, important methods of preparation, comparative reactivity of acid derivatives. Some commercially important compounds.

26. Organic Compounds with functional group containing nitrogen

- Structure, nomenclature of nitro, amino, cyano and diazo compounds.
- Nitro compounds – important methods of preparation, physical properties and chemical reactions.
- Amines : primary, secondary and tertiary amines, a general awareness, important methods of preparation, physical properties, basic character of amines, chemical reactions.
- Cyanides and isocyanides : preparation, physical properties and chemical reactions.
- Diazonium salts : Preparation, chemical reaction and uses of benzene diazonium chloride. Some commercially important nitrogen containg carbon compounds, (aniline, TNT)

27. Polymers

Classification of polymers, general methods of polymerization-addition and condensation: addition-free radical, cationic, anionic polymerization, copolymerisation, natural rubber, vulcanization of rubber, synthetic rubbers, condensation polymers, idea of macromolecules, biodegradable polymers.

Some commercially important polymers (PVC, teflon, polystyrene, nylon-6 and 66, terylene and bakelite).

28. Environmental Chemistry

Environmental pollution – air, water and soil pollutions, chemical reactions in atmosphere, smogs, major atmospheric pollutants, acid-rain, ozone and its reactions, effects of depletion of ozone layer, green house effect and global warming – pollution due to industrial wastes, green chemistry as an alternative tool for reducing pollution, strategy for controlling environmental pollution.

29. Biomolecules

Carbohydrates : Classification, aldose and ketose, monosaccharides (glucose and fructose), oligosaccharides (sucrose, lactose, maltose), polysaccharides (starch, cellulose, glycogen); important simple chemical reactions of glucose, elementary idea of structure of pentose and hexose.

Proteins : Elementary idea of α-amino acids, peptide bond, polypeptides, proteins; primary, secondary and tertiary structure of proteins and quaternary structure (gualitative idea only), denaturation of proteins, enzymes.

Vitamins : Classification and functions

Nucleic acids : Chemical composition of DNA and RNA

Lipids : Classification and structure

Hormones : Classification and functions in biosystem.

30. Chemistry in everyday life

- Chemicals in medicines – analgesics, tranquilizers, antiseptics, disinfectants, antimicrobials, antifertility drugs, antacids, antihistamins.
- Chemicals in food – preservativess, artificial sweetening agents.
- Cleansing agents – soaps and detergents, cleansing action.
- Rocket propellants : characteristics and chemicals used.