BITSAT Chemistry Syllabus in pdf format

1. States of Matter

1.1 Measurement: Physical quantities and SI units, Dimensional analysis, Precision, Significant figures.

1.2 Chemical reactions: Laws of chemical combination, Dalton's atomic theory; Mole concept; Atomic, molecular and molar masses; Percentage composition empirical & molecular formula; Balanced chemical equations & stoichiometry

1.3 Gaseous state: Gas Laws, ideal behavior, empirical derivation of gas equation, Kinetic theory – Maxwell distribution of velocities, Average, root mean square and most probable velocities and relation to temperature, Diffusion; Deviation from ideal behaviour – Critical temperature, Liquefaction of gases, van der Waals equation.

1.4 Liquid state: Vapour pressure, surface tension, viscosity.

1.5 Solid state: Classification; Space lattices & crystal systems; Unit cell – Cubic & hexagonal systems; Close packing; Crystal structures: Simple AB and AB2 type ionic crystals, covalent crystals – diamond & graphite, metals. Imperfections- Point defects, non-stoichiometric crystals; Electrical, magnetic and dielectric properties; Amorphous solids – qualitative description. Band theory of metals, conductors, semiconductors and insulators, and n- and p-type semiconductors.

2. Atomic Structure

2.1 Introduction: Radioactivity, Subatomic particles; Atomic number, isotopes and isobars, Rutherford's picture of atom; Hydrogen atom spectrum and Bohr model.

2.2 Quantum mechanics: Wave-particle duality – de Broglie relation, Uncertainty principle; Hydrogen atom: Quantum numbers and wavefunctions, atomic orbitals and their shapes (s, p, and d), Spin quantum number.

2.3 Many electron atoms: Pauli exclusion principle; Aufbau principle and the electronic configuration of atoms, Hund's rule.

2.4 Periodicity: Periodic law and the modern periodic table; Types of elements: s, p, d, and f blocks; Periodic trends: ionization energy, atomic and ionic radii, electron affinity, electro negativity and valency.

3. Chemical Bonding & Molecular Structure

3.1 Ionic Bond: Lattice Energy and Born-Haber cycle; Covalent character of ionic bonds and polar character of covalent bond

3.2 Molecular Structure: Lewis picture & resonance structures, VSEPR model & molecular shapes

3.3 Covalent Bond: Valence Bond Theory- Orbital overlap, Directionality of bonds & hybridization (s, p & d orbitals only), Resonance; Molecular orbital theory- Methodology, Orbital energy level diagram, Bond order, Magnetic properties for homonuclear diatomic species.

3.4 Metallic Bond: Qualitative description.

3.5 Intermolecular Forces: Polarity; Dipole moments; Hydrogen Bond.

4. Thermodynamics

4.1 Basic Concepts: Systems and surroundings; State functions; Intensive & Extensive Properties; Zeroth Law and Temperature

4.2 First Law of Thermodynamics: Work, internal energy, heat, enthalpy, heat capacities; Enthalpies of formation, phase transformation, ionization, electron gain; Thermochemistry; Hess's Law. Bond dissociation, combustion, atomization, sublimation, dilution

4.3 Second Law: Spontaneous and reversible processes; entropy; Gibbs free energy related to spontaneity and non-mechanical work; Standard free energies of formation, free energy change and chemical equilibrium

4.4 Third Law: Introduction

5. Physical and Chemical Equilibria

5.1 Concentration Units: Mole Fraction, Molarity, and Molality

5.2 Solutions: Solubility of solids and gases in liquids, Vapour Pressure, Raoult's law, Relative lowering of vapour pressure, depression in freezing point; elevation in boiling point; osmotic pressure, determination of molecular mass; solid solutions.

5.3 Physical Equilibrium: Equilibria involving physical changes (solid-liquid, liquid-gas, solid-gas), Surface chemistry, Adsorption, Physical and Chemical adsorption, Langmuir Isotherm, Colloids and emulsion, classification, preparation, uses.

5.4 Chemical Equilibria: Equilibrium constants (K_P, K_C), Le-Chatelier's principle.

5.5 Ionic Equilibria: Strong and Weak electrolytes, Acids and Bases (Arrhenius, Lewis, Lowry and Bronsted) and their dissociation; Ionization of Water; pH; Buffer solutions; Acid-base titrations; Hydrolysis; Solubility Product of Sparingly Soluble Salts; Common Ion Effect.

5.6 Factors Affecting Equilibria: Concentration, Temperature, Pressure, Catalysts, Significance of DG andDG^0 in Chemical Equilibria.

6. Electrochemistry

6.1 Redox Reactions: Oxidation-reduction reactions (electron transfer concept); Oxidation number; Balancing of redox reactions; Electrochemical cells and cell reactions; Electrode potentials; EMF of Galvanic cells; Nernst equation; Factors affecting the electrode potential; Gibbs energy change and cell potential; Secondary cells; Fuel cells; Corrosion and its prevention.

6.2 Electrolytic Conduction: Electrolytic Conductance; Specific and molar conductivities; Kolhrausch's Law and its application, Faraday's laws of electrolysis; Coulometer; Electrode potential and electrolysis, Commercial production of the chemicals, NaOH, Na, Al, Cl_2 & F_2.

7. Chemical Kinetics

7.1 Aspects of Kinetics: Rate and Rate expression of a reaction; Rate constant; Order and molecularity of the reaction; Integrated rate expressions and half life for zero and first order reactions.

7.2 Factor Affecting the Rate of the Reactions: Concentration of the reactants, size of particles; Temperature dependence of rate constant; Activation energy; Catalysis, Surface catalysis, enzymes, zeolites; Factors affecting rate of collisions between molecules.

7.3 Mechanism of Reaction: Elementary reactions; Complex reactions; Reactions involving two/three steps only.

8. Hydrogen and s-block elements

8.1 Hydrogen: Element: unique position in periodic table, occurrence, isotopes; Dihydrogen: preparation, properties, reactions, and uses; Molecular, saline, ionic, covalent, interstitial hydrides; Water: Properties; Structure and aggregation of water molecules; Heavy water; Hydrogen peroxide: preparation, reaction, structure & use, Hydrogen as a fuel.

8.2 s-block elements: Abundance and occurrence; Anomalous properties of the first elements in each group; diagonal relationships; trends in the variation of properties (ionization energy, atomic & ionic radii).

8.3 Alkali metals: Lithium, sodium and potassium: occurrence, extraction, reactivity, and electrode potentials; Biological importance; Reactions with oxygen, hydrogen, halogens water and liquid ammonia; Basic nature of oxides and hydroxides; Halides; Properties and uses of compounds such as NaCl, Na_2CO_3, $NaHCO_3$, NaOH, KCl, and KOH.

8.4 Alkaline earth metals: Magnesium and calcium: Occurrence, extraction, reactivity and electrode potentials; Reactions with non-metals; Solubility and thermal stability of oxo salts; Biological importance; Properties and uses of important compounds such as CaO, $Ca(OH)_2$, plaster of Paris, $MgSO_4$, $MgCl_2$, $CaCO_3$, and $CaSO_4$; Lime and limestone, cement.

9. p- d- and f-block elements

9.1 General: Abundance, distribution, physical and chemical properties, isolation and uses of elements; Trends in chemical reactivity of elements of a group; electronic configuration, oxidation states; anomalous properties of first element of each group.

9.2 Group 13 elements: Boron; Properties and uses of borax, boric acid, boron hydrides & halides. Reaction of aluminum with acids and alkalis;

9.3 Group 14 elements: Carbon: carbon catenation, physical & chemical properties, uses, allotropes (graphite, diamond, fullerenes), oxides, halides and sulphides, carbides; Silicon: Silica, silicates, silicone, silicon tetrachloride, Zeolites.

9.4 Group 15 elements: Dinitrogen; Reactivity and uses of nitrogen and its compounds; Industrial and biological nitrogen fixation; Ammonia: Haber's process, properties and reactions; Oxides of nitrogen and their structures; Ostwald's process of nitric acid production; Fertilizers – NPK type; Production of phosphorus; Allotropes of phosphorus; Preparation, structure and properties of hydrides, oxides, oxoacids (elementary idea only) and halides of phosphorus, phosphine.

9.5 Group 16 elements: Isolation and chemical reactivity of dioxygen; Acidic, basic and amphoteric oxides; Preparation, structure and properties of ozone; Allotropes of sulphur; Production of sulphur and sulphuric acid; Structure and properties of oxides, oxoacids (structures only), hydrides and halides of sulphur.

9.6 Group 17 and group 18 elements: Structure and properties of hydrides, oxides, oxoacids of chlorine (structures only); preparation, properties & uses of chlorine & HCl; Inter halogen compounds; Bleaching Powder; Preparation, structure and reactions of xenon fluorides, oxides, and oxoacids.

9.7 d-Block elements: General trends in the chemistry of first row transition elements; Metallic character; Oxidation state; ionization enthalpy; Ionic radii; Catalytic properties; Magnetic properties; Interstitial compounds; Occurrence and extraction of iron, copper, silver, zinc, and mercury; Alloy formation; Steel and some important alloys; preparation and properties of $CuSO_4$, $K_2Cr_2O_7$, $KMnO_4$, Mercury halides; Silver nitrate and silver halides; Photography.

9.8 f-Block elements: Lanthanoids and actinoids; Oxidation states and chemical reactivity of lanthanoids compounds; Lanthanide contraction; Comparison of actinoids and lanthanoids.

9.9 Coordination Compounds: Coordination number; Ligands; Werner's coordination theory; IUPAC nomenclature; Application and importance of coordination compounds (in qualitative analysis, extraction of metals and biological systems e.g. chlorophyll, vitamin B12, and hemoglobin); Bonding: Valence-bond approach, Crystal field theory (qualitative); Stability constants; Shapes, color and magnetic properties; Isomerism including stereoisomerisms;

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Organometallic compounds.

10. Principles of Organic Chemistry and Hydrocarbons

10.1 Classification: Based on functional groups, trivial and IUPAC nomenclature. Methods of purification: qualitative and quantitative.

10.2 Electronic displacement in a covalent bond: Inductive, resonance effects, and hyperconjugation; free radicals; carbocations, carbanions, nucleophiles and electrophiles; types of organic reactions.

10.3 Alkanes and cycloalkanes: Structural isomerism, general properties and chemical reactions.

10.4 Alkenes and alkynes: General methods of preparation and reactions, physical properties, electrophilic and free radical additions, acidic character of alkynes and (1,2 and 1,4) addition to dienes.

10.5 Aromatic hydrocarbons: Sources; properties; isomerism; resonance delocalization; aromaticity; polynuclear hydrocarbons; mechanism of electrophilic substitution reaction, directive influence and effect of substituents on reactivity; carcinogenicity and toxicity.

10.6 Haloalkanes and haloarenes: Physical properties, chemical reactions and mechanism of substitution reaction. Uses and environmental effects; di, tri, tetrachloromethanes, iodoform, freon and DDT.

10.7 Petroleum: Composition and refining, uses of petrochemicals.

11. Stereochemistry

11.1 Introduction: Chiral molecules; optical activity; polarimetry; R,S and D,L configurations; Fischer projections; enantiomerism; racemates; diastereomerism and meso structures.

11.2 Conformations: Ethane conformations; Newman and Sawhorse projections.

11.3 Geometrical isomerism in alkenes

12. Organic Compounds with Functional Groups Containing Oxygen and Nitrogen

12.1 General: Electronic structure, important methods of preparation, identification, important reactions, physical properties and uses of alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, nitro compounds, amines, diazonium salts, cyanides and isocyanides.

12.2 Specific: Effect of substituents on alpha-carbon on acid strength, comparative reactivity of acid derivatives, mechanism of nucleophilic addition and dehydration, basic character of amines methods of preparation, and their separation, importance of diazonium salts in synthetic organic chemistry.

13. Biological , Industrial and Environmental chemistry

13.1 The Cell: Concept of cell and energy cycle.

13.2 Carbohydrates: Classification; Monosaccharides; Structures of pentoses and hexoses; Anomeric carbon; Mutarotation; Simple chemical reactions of glucose, Disaccharides: reducing and non-reducing sugars – sucrose, maltose and lactose; Polysaccharides: elementary idea of structures of starch, cellulose and glycogen.

13.3 Proteins: Amino acids; Peptide bond; Polypeptides; Primary structure of proteins; Simple idea of secondary , tertiary and quarternary structures of proteins; Denaturation of proteins and enzymes.

13.4 Nucleic Acids: Types of nucleic acids; Primary building blocks of nucleic acids (chemical composition of DNA & RNA); Primary structure of DNA and its double helix; Replication; Transcription and protein synthesis; Genetic code.

13.5 Vitamins: Classification, structure, functions in biosystems; Hormones

13.6 Polymers: Classification of polymers; General methods of polymerization; Molecular mass of polymers; Biopolymers and biodegradable polymers; Free radical, cationic and anionic addition polymerizations; Copolymerization: Natural rubber; Vulcanization of rubber; Synthetic rubbers. Condensation polymers.

13.7 Pollution: Environmental pollutants; soil, water and air pollution; Chemical reactions in atmosphere; Smog; Major atmospheric pollutants; Acid rain; Ozone and its reactions; Depletion of ozone layer and its effects; Industrial air pollution; Green house effect and global warming; Green Chemistry.

13.8 Chemicals in medicine, health-care and food: Analgesics, Tranquilizers, antiseptics, disinfectants, anti-microbials, anti-fertility drugs, antihistamines, antibiotics, antacids; Preservatives, artificial sweetening agents, antioxidants, soaps and detergents.

14. Theoretical Principles of Experimental Chemistry

14.1 Volumetric Analysis: Principles; Standard solutions of sodium carbonate and oxalic acid; Acid-base titrations; Redox reactions involving KI, H_2SO_4, Na_2SO_3, $Na_2S_2O_3$and H_2S; Potassium permanganate in acidic, basic and neutral media; Titrations of oxalic acid, ferrous ammonium sulphate with $KMnO_4$, $K_2 Cr_2O_7/Na_2S_2O_3$, $Cu(II)/Na_2S_2O_3$.

14.2 Qualitative analysis of Inorganic Salts: Principles in the determination of the cations Pb^{2+}, Cu^{2+}, As^{3+}, Mn^{2+}, Zn^{2+}, Co^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, NH_4^+, Fe^{3+}, Ni^{2+} and the anions CO_3^{2-}, S^{2-}, SO_4^{2-}, SO_3^{2-}, NO_2^-, NO_3^-, Cl^-, Br^-, I^-, PO_4^{3-}, CH_3COO^-, $C_2O_4^{2-}$.

14.3 Physical Chemistry Experiments: preparation and crystallization of alum, copper sulphate, ferrous sulphate, double salt of alum and ferrous sulphate, potassium ferric sulphate;

Temperature vs. solubility; pH measurements; Lyophilic and lyophobic sols; Dialysis; Role of emulsifying agents in emulsification. Equilibrium studies involving (i) ferric and thiocyanate ions (ii) $[Co(H_2O)_6]^{2+}$ and chloride ions; Enthalpy determination for (i) strong acid vs. strong base neutralization reaction (ii) hydrogen bonding interaction between acetone and chloroform; Rates of the reaction between (i) sodium thiosulphate and hydrochloric acid, (ii) potassium iodate and sodium sulphite (iii) iodide vs. hydrogen peroxide, concentration and temperature effects in these reactions.

14.4 Purification Methods: Filtration, crystallization, sublimation, distillation, differential extraction, and chromatography. Principles of melting point and boiling point determination; principles of paper chromatographic separation – R_f values.

14.5 Qualitative Analysis of Organic Compounds: Detection of nitrogen, sulphur, phosphorous and halogens; Detection of carbohydrates, fats and proteins in foodstuff; Detection of alcoholic, phenolic, aldehydic, ketonic, carboxylic, amino groups and unsaturation.

14.6 Quantitative Analysis of Organic Compounds: Basic principles for the quantitative estimation of carbon, hydrogen, nitrogen, halogen, sulphur and phosphorous; Molecular mass determination by silver salt and chloroplatinate salt methods; Calculations of empirical and molecular formulae.

14.7 Principles of Organic Chemistry Experiments: Preparation of iodoform, acetanilide, p-nitro acetanilide, di-benzayl acetone, aniline yellow, beta-naphthol; Preparation of acetylene and study of its acidic character.

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