NEST 2019 Syllabus

Chemistry:

Physical Chemistry:

Measurements in chemistry - SI units for fundamental quantities, significant figures in calculations.

Mole concept - Avogadro number and mole concept, molar masses, mole fraction, molarity, molality, percent composition, stoichiometry. Equivalent weight and normality. Calculations based on mole concept and stoichiometry of different reactions. Oxidation – reduction reactions.

Gaseous and liquid states - Absolute scale of temperature. Gas laws, ideal gas equation, real gases and deviation from ideality, liquefaction of gases, van der Waals equation. Kinetic theory of gases; average, root mean square and most probable velocities and their relation with temperature. Law of partial pressures. Vapour pressure. Diffusion of gases.

Atomic structure and chemical bonding - Bohr model, spectrum of hydrogen atom, quantum numbers. Wave particle duality, de Broglie hypothesis. Uncertainty principle. Orbitals and quantum numbers; shapes and energy of s, p and d orbitals. Electronic configurations of elements (up to atomic number 36), filling of orbitals – Aufbau principle. Pauli's exclusion principle and Hund's rule. Hybridization involving s, p and d orbitals. Atomic orbital overlap and chemical bonds; ionic, covalent and coordinate bonds; bond parameters. Orbital energy diagrams for homo – nuclear diatomic species. Lewis structures. Hydrogen bond. Polarity in molecules, dipole moment (qualitative aspects). VSEPR theory and shapes of molecules. Valence Bond Theory. Molecular orbital theory of homo – nuclear diatomic molecules (qualitative idea).

Thermodynamics - Thermodynamic states. First law of thermodynamics. Internal energy, work and heat, pressure – volume work. Enthalpy and enthalpy change, Hess's law, heat of

– reaction, fusion and vaporisation. Second law of thermodynamics, entropy, free energy, criterion of spontaneity.

Chemical equilibrium - Laws of chemical Equilibrium, law of mass action. Equilibrium constant – factors affecting equilibrium constant and its applications. Le Chatelier's principle - effect of concentration, temperature and pressure. Significance of ΔG and ΔG^o in chemical equilibrium. Relationship of K and ΔG. Ionic equilibrium. Acids and bases (Bronsted and Lewis concepts), salts. Ka, Kb, Kw, degree of dissociation, pH and their relationships. Solubility product, common ion effect. Hydrolysis of salts. Buffer solutions.

Electrochemistry - Redox reactions and electrode potential, Electrochemical cells, Galvanic cells and cell reactions. Standard electrode potential. Nernst equation and its relation to ΔG and K. Electrochemical series, emf of galvanic cells. Electrolysis and Faraday's laws of electrolysis. Electrolytic conductance, specific, equivalent and molar conductivity, Kohlrausch's law. Concentration cells. Batteries (primary and secondary), fuel cells, corrosion.

Chemical kinetics - Rates of chemical reactions. Order of reaction, rate constant. First order and pseudo first order reactions. Factors affecting rate of reaction – concentration, temperature (Arrhenius equation), catalyst.

Solid state - Classification of solids, amorphous and crystalline solids, crystalline state, crystal lattice and unit cells; seven crystal systems (cell parameters a, b, c, α, β,), close packed structure of solids (cubic), packing in fcc, bcc and hcp lattices. Packing efficiency, nearest neighbours, ionic radii. Simple ionic compounds, Imperfection in solids, point defects. Electrical and magnetic properties, band theory of metals.

Solutions - Solution of solid and gas in liquid. Concentration of solution. Ideal and non-ideal solutions. Colligative properties. Vapour pressure of solution, Raoult's law. Molecular weight determination from lowering of vapour pressure, elevation of boiling point and depression of freezing point. Abnormal molecular mass, vant Hoff factor. Osmosis – Osmotic pressure, reverse osmosis.

Surface chemistry:

(a) **Adsorption** – Physisorption and chemisorptions. Factors affecting adsorption of gases on solids. Adsorption isotherm. Catalysis – homogeneous and heterogeneous, Activity and selectivity. Enzyme catalysis.

(b) Colloidal state – Types, preparation and properties of colloids. Tyndall effect, Brownian movement, electrophoresis, coagulation. Application of colloids. Micelles.

Inorganic Chemistry:

Classification of elements and periodicity in properties - Modern periodic table, classification of elements, periodic trends in properties of elements – valence, oxidation state, atomic/ionic radius, ionization energy, electron gain energy, electronegativity, valency, chemical reactivity. Diagonal relationship. Anomalous behaviours of Li, Be, B, C.

Hydrogen - Isotopes, preparation, isolation, properties and uses. Hydrides – ionic, covalent and interstitial. Properties of water and heavy water. Hydrogen peroxide – Preparation, structure, reactions, uses. Hydrogen as fuel cell.

s – Block elements (Alkali and alkaline earth elements) – General characteristics and trends in properties.

(a) Group 1: Preparation, properties and reactions of alkali metals with emphasis on chemistry of Na and K and their compounds – oxides, peroxides, hydroxides, carbonates, bicarbonates, chlorides and sulphates. Uses.

(b) Group 2: Preparation, properties and reactions alkaline earth metals with emphasis on the chemistry of Mg and Ca and their compounds – oxides, peroxides, hydroxides, carbonates, bicarbonates, chlorides and sulphates. Uses.

p – Block elements - General characteristics and trends in properties.

(**a) Group 13:** Chemistry of Boron and its compounds – borax, boric acid and diborane.

(b) Group 14, 15 and 16: Chemistry of carbon, sulphur, nitrogen and phosphorus. Allotropy. Chemistry of oxides and oxyacids of these elements. Phosphines, phosphorus chlorides, ammonia, peroxide and ozone; silicones, silicon tetrachloride and silicates.

(c) Group 17: Chemistry of halogens, chemistry of chlorine in detail. Interhalogen compounds. HX and oxyacids of halogens.

(d) Group 18: Isolation, properties and reactions of inert gases with emphasis on chemistry of Xenon.

d – Block elements - (Mainly 3d elements) General characteristics and trends in properties. Variable oxidation states and their stabilities, colour (excluding the details of electronic transitions) and calculation of spin – only magnetic moment. Catalytic properties. Interstitial compounds, alloy formation. Preparation and properties of potassium dichromate and permanganate.

f – Block elements- (mainly lanthanides) General characteristics and trends in properties. Variable oxidation states. Lanthanide contraction and its consequences.

Coordination compounds -Nomenclature of mononuclear coordination compounds. Isomerism. Hybridization and geometries of mononuclear coordination compounds. Magnetic properties. Werner’ s theory, VBT, CFT.

Metals and metallurgy - Occurrence of metals. General methods of extraction involving chemical principles – thermodynamic, electrochemical and redox principles. General operation stages involved in metallurgical operation. Metallurgy of p – block element (emphasis on Al). Metallurgy of Fe – triad (more emphasis on Fe metallurgy). Metallurgy of coinage metals (Cu, Ag with more emphasis on Cu). Refining.

Organic Chemistry:

Basic concepts - Representation of organic compounds. Hybridisations of carbon. Sigma and pi – bonds. Shapes of simple organic molecules. Inductive effect, electromeric effect, resonance effect, hyperconjugation. Keto – enol tautomerism. Determination of empirical and molecular formulae (only combustion method). Hydrogen bond – definition and effect on physical properties of alcohols and carboxylic acids. Acidity and basicity of organic acids and bases. Methods of purification of compounds.

Reactive intermediates - Homolytic and heterolytic bond cleavages. Formation, structure and stability of – carbocation, carbanion and free radical.

Isomerism - Structural and stereoisomerism. Geometrical isomerism. Chirality. Enantiomers. Optical isomerism of compounds containing up to two asymmetric centres, (R, S and E, Z nomenclature excluded). Racemic mixture. Conformations of ethane and butane (Newman projections).

Nomenclature - IUPAC nomenclature of simple organic compounds (only hydrocarbons, mono – functional and bi – functional compounds), including benzene derivatives.

Alkanes - Preparation, properties and reactions. Idea of homologous series Combustion and halogenation of alkanes. Mechanism of photohalogenation, Wurtz reaction.

Alkenes and Alkynes - Preparation, properties and reactions of alkenes and alkynes. Isomerization. Acidity of alkynes. Acid catalysed hydration of alkenes and alkynes (excluding the stereochemistry), Reactions of alkenes with KMnO4, sulphuric acid, Reduction of alkenes and alkynes, Preparation of alkenes and alkynes by elimination reactions (excluding stereochemistry), Electrophilic addition reactions of alkenes with X2, HX, HOX and H2O (X=halogen). Makowniko rule. Peroxide effect. Polymerization of alkenes, Addition reactions of alkynes, Metal acetylides, Ozonolysis

Aromatic compounds - Aromaticity. Huckel theory of aromaticity. Structure of benzene. Isomerism in substituted benzenes. Electrophilic substitution reaction on benzene – General mechanism. Orientating influence of substituents in electrophilic substitution reaction of monosubstituted benzenes. Electrophilic substitution reactions of benzene and substituted benzenes – halogenation, nitration, sulphonation, Friedel – Crafts alkylation and acylation (No mechanism).

Haloalkanes (Alkyl halides) - Preparation from alkanes, alcohols, ole ns. Grignard reagents and their reaction with aldehydes/ketones/esters/nitriles. Nucleophilic substitution reactions of alkyl halides with different nucleophilic species. SN1 and SN2 reactions with mechanism. Halogen exchange reaction. Polyhalogen compounds.

Haloarenes - Nucleophilic aromatic substitution in haloarenes and substituted haloarenes (excluding Benzyne mechanism and Cine substitution).

Alcohols - Preparation from – ole ns, alkyl halides, carboxylic acids, aldehydes/ketones. Hydroboration reaction. Dehydration, oxidation to aldehydes and ketones. Reaction with sodium, phosphorus halides, $ZnCl_2$/ HX, H_2SO_4. Identification of p –, sec – and tert – alcohols. Uses of methanol and ethanol.

Phenols - Preparation of phenol from halobenzene, cumene and benzene sulphonic acid. Acidity. Reactions of phenols – halogenation, nitration, sulphonation, with Zn. Reimer – Tieman reaction, Kolbe reaction.

Ethers - Preparation by Williamson's Synthesis, dehydration of alcohols. Reaction with H_2O, HX.

Aldehydes and Ketones – Preparation of aldehydes and ketones from – Alcohols, olefins, acid chlorides, arylalkanes, nitriles, esters, Friedel – Crafts reaction. Reactions with – Alcohols,

HCN, NaHSO3. Reactions – oxidation, reduction, oxime and hydrazone formation. Aldol condensation, Perkin reaction. Cannizzaro reaction. Haloform reaction. Tests to distinguish aldehydes and ketones.

Carboxylic acids – Acidity and structure – acidity relationship. Preparation of acids. Preparation of amides, acid chlorides, esters and anhydrides. ester hydrolysis. Reactions of acids with – thionyl chloride, P – halides, ammonia, alkalis, metals, halogens, reducing agents. Decarboxylation. Halogenation.

Amines – Basicity and structure – basicity relationship. Identification of p – , sec – and tert – amines. Preparation of amines from – nitro compounds, nitriles, amides, haloalkanes/aromatic compounds. Reaction with – Acids, alkylating agents, acylating agents, nitrous acid. Diazotization of aromatic primary amines – Reactions of aromatic diazonium salts – azo coupling reaction, Sandmeyer and related reactions. Carbylamine reaction of p – amines.

Carbohydrate - Classification of carbohydrates. mono – and di – saccharides (glucose and sucrose). Characteristic tests. Structure of glucose. Reactions of glucose – Oxidation, reduction, hydroxylamine, HI, acetic anhydride. Cyclic structure of glucose. Structures of – Sucrose, maltose, starch and cellulose. Glycoside formation and hydrolysis of sucrose.

Amino acids and proteins - α – amino acids. General structure of peptides and proteins. Peptide bond. Characteristic tests. Separation of amino acids using physical properties. Denaturation of proteins. Enzymes.

Polymers: Classification. Homo and co – polymers, Addition and condensation polymerizations. Polythene, nylons, polyesters, Bakelite, melamine – formaldehyde, rubber – natural and synthetic.