APPENDIX – 1

WEST BENGAL JOINT ENTRANCE EXAMINATIONS BOARD

SYLLABUS FOR JEM - 2009

CHEMISTRY

Atoms, Molecules and Chemical Arithmetic :

Dalton's atomic theory; Gay Lussac's law of gaseous volume; Avogadro's Hypothesis and its applications.

Atomic mass; Molecular mass; Equivalent weight; Valency; Gram atomic weight; Gram molecular weight; Gram equivalent weight and mole concept; Chemical formulae; Balanced chemical equations; Calculations (based on mole concept) involving common oxidation-reduction, neutralization, and displacement reactions; Concentration in terms of mole fraction, molarity, molality and normality.

Percentage composition, empirical formula and molecular formula; Numerical problems.

Atomic Structure

Concept of Nuclear Atom – electron, proton and neutron (charge and mass), atomic number; Rutherford's model and its limitations; Extra nuclear structure; Line spectra of hydrogen atom.

Quantization of energy (Planck's equation $E = h\nu$); Bohr's model of hydrogen atom and its limitations, Sommerfelds modifications (elementary idea); The four quantum numbers, ground state electronic configurations of many electron atoms and mono-atomic ions; The Aufbau Principle; Pauli's Exclusion Principle and Hund's Rule.

Uncertainty principle; The concept of atomic orbitals, shapes of *s, p* and *d* orbitals (pictorial approach)

Radioactivity and Nuclear Chemistry

Radioactivity – α-, β-, γ-rays and their properties; Artificial transmutation; Rate of radioactive decay, decay

constant, half-life and average life period of radio-elements; Units of radioactivity; Numerical problems.

Stability of the atomic nucleus – effect of neutron–proton (n/p) ratio on the modes of decay, group displacement law, radioisotopes and their uses (C, P, Co and I as examples) isobars and isotones (definition and examples), elementary idea of nuclear fission and fusion reactions.

The Periodic Table and Chemical Families

Modern periodic law (based on atomic number); Modern periodic table based on electronic configurations, groups (Gr. 1–18) and periods. Types of elements-representative (s-block and p-block), transition (d-block) elements and inner transition (f-block / lanthanides and actinides) and their general characteristics. Periodic trends in physical and chemical properties–atomic radii, valency, ionization energy, electron affinity,

electronegativity, metallic character, acidic and basic characters of oxides and hydrides of the representative elements (up to Z = 36). Position of hydrogen and the noble gases in the periodic table; Diagonal relationships.

Chemical Bonding and Molecular Structure
Valence electrons, the Octet rule, electrovalent, covalent and coordinate covalent bonds with examples; Properties of electrovalent and covalent compounds. Limitations of Octet rule (examples); Fajan's Rule.

Directionality of covalent bonds, shapes of poly-atomic molecules (examples); Concept of hybridization of atomic orbitals (qualitative pictorial approach) : sp, sp^2, sp^3 and dsp^2.

Molecular orbital energy diagrams for homonuclear diatomic species – bond order and magnetic properties.

Valence Shell Electron Pair Repulsion (VSEPR) concept (elementary idea) – shapes of molecules. Concept of resonance (elementary idea), resonance structures (examples). Elementary idea about electronegativity, bond polarity and dipole moment, inter- and intra- molecular hydrogen bonding and its effects on physical properties (mp, bp and solubility); Hydrogen bridge bonds in diborane.

Double salts and complex salts, co-ordination compounds (examples only), co-ordination number (examples of co-ordination number 4 and 6 only).

Gaseous state
Measurable properties of gases. Boyle's Law and Charles Law, absolute scale of temperature, kinetic theory of gases, ideal gas equation – average, root mean square and most probable velocities and their relationship with temperature.

Dalton's Law of partial pressure, Graham's Law of gaseous diffusion. Deviations from ideal behavior.

Liquefaction of gases, real gases, van der Waal's equation; Numerical problems.

Chemical Energetics and Chemical Dynamics
Chemical Energetics – conservation of energy principle, energy changes in physical and chemical transformations. First law of thermodynamics; Internal energy, work and heat, pressure-volume work; Enthalpy. Internal energy change (ΔE) and Enthalpy change (ΔH) in a chemical reaction. Hess's Law and its applications (Numerical problems). Heat of reaction, fusion and vapourization; Second law of thermodynamics; Entropy; Free energy; Criterion of spontaneity.

Chemical Equilibria – The Law of mass action, dynamic nature of chemical equilibria. Equilibrium constants, Le Chatelier's Principle. Equilibrium constants of gaseous reactions (K_p and K_c) and relation between them (examples). Significance of ΔG and $\Delta G°$.

Chemical Dynamics **– Factors affecting the rate of chemical reactions (concentration, pressure, temperature, catalyst). Arrhenius equation and concept of activation energy.**

Order and molecularity (determination excluded); First order reactions, rate constant, half-life (numerical problems), examples of first order and second order reactions.

Physical Chemistry of Solutions
Colloidal Solutions – differences from true solutions; Hydrophobic and hydrophilic colloids (examples and uses); Coagulation and peptization of colloids; Dialysis and its applications; Brownian motion; Tyndall effect and its applications; Elementary idea of emulsion, surfactant and micelle.

Electrolytic Solutions – Specific conductance, equivalent conductance, ionic conductance, Kohlrausch's law, Faraday's laws of electrolysis, applications. Numerical problems.

Non-electrolytic Solutions – Types of solution, vapour pressure of solutions. Raoult's Law; Colligative properties – lowering of vapour pressure, elevation of boiling point, depression of freezing point, osmotic pressure and their relationships with molecular mass (without derivations); Numerical problems.

Ionic and Redox Equilibria
Ionic equilibria – ionization of weak electrolytes, Ostwald's dilution law. Ionization constants of weak acids and bases, ionic product of water, the pH – scale, pH of aqueous solutions of acids and bases; Buffer solutions, buffer action and Henderson equation.

Acid-base titrations, acid-base indicators (structures not required).
Solubility and Solubility Products.
Common ion effect (no numerical problems).

Redox Equilibria **– Oxidation-Reduction reactions as electron transfer processes, oxidation numbers, balancing of redox reactions by oxidation number and ion-electron methods.**
Standard electrode potentials (E°), Electrochemical series, feasibility of a redox reaction.
Significance of Gibb's equation : $\Delta G^\circ = -nF\Delta E^\circ$ (without derivation), no numerical problems.
Redox titrations with (examples); Nernst equations (Numerical problems).

Chemistry of Non-metallic Elements and their Compounds
Carbon – occurrence, isotopes, allotropes (graphite, diamond, fullerene); CO and CO_2 production, properties and uses.
Nitrogen and Phosphorus – occurrence, isotopes, allotopes, isolation from natural sources and purification, reactivity of the free elements. Preparation, properties, reactions of NH_3, PH_3 , NO, NO_2 , HNO_2, HNO_3, P_4O_{10}, H_3PO_3 and H_3PO_4.

Oxygen and Sulfur – Occurrence, isotopes, allotropic forms, isolation from natural sources and purification, properties and reactions of the free elements. Water, unusual properties of water, heavy water (production and uses). Hydrogen peroxide and ozone (production, purification, properties and uses).

Halogen
Halogens – comparative study, occurrence, physical states and chemical reactivities of the free elements, peculiarities of fluorine and iodine; Hydracids of halogens (preparation, properties, reactions and uses), inter-halogen compounds (examples); Oxyacids of chlorine.

Chemistry of metals :

General principles of metallurgy – occurrence, concentration of ores, production and purification of metals, mineral wealth of India.

Typical metals (Na, Ca, Al, Fe, Cu and Zn) – occurrence, extraction, purification (where applicable), properties and reactions with air, water, acids and non-metals.

Manufacture of steels and alloy steel (Bessemer, Open-Hearth and L.D. process).

Principles of chemistry involved in electroplating, anodizing and galvanizing.

Chemistry in Industry
Large scale production (including physicochemical principles where applicable omitting technical details and uses of individual items).

Heavy chemicals : Sulfuric acid (contact process), Ammonia (Haber's process), Nitric acid (Ostwald's process), sodium bi-carbonate and sodium carbonate (Solvey process).

Polymers, Polythene, Nylon-66, rubber from natural source, vulcanization.

Electrochemicals – sodium hydroxide, chlorine, bleaching powder as by-products.

Fuel Gases – LPG, CNG.

Silicon carbide and silicones.

Environmental Chemistry
Common modes of pollution of air, water and soil. Ozone layer, ozone hole – important chemical reactions. Green House effect; Smog; Pollution of water by domestic and industrial effluents; Pollutants–pesticides, fertilizers and plastics.

Chemistry of carbon compounds

Hybridization of carbon – σ- and π-bonds.

Isomerism – constitutional and stereoisomerism; Geometrical and optical isomerism of compounds containing upto two asymmetric carbon atoms. IUPAC nomenclature of simple organic compounds– hydrocarbons, mono and bifunctional molecules only (alicyclic and heterocyclic compounds excluded). Conformations of ethane and n-butane (Newman projection only).

Electronic effects – inductive, resonance and hyperconjugation. Stability of carbocation, carbanion and free radicals; Rearrangement of carbocation; Electrophiles and nucleophiles, tautomerism in β-dicarbonyl compounds, acidity and basicity of simple organic compounds.

Aliphatic Compounds

Alkanes – Preparation from alkyl halides and carboxylic acids; Reactions – halogenation and combustion.

Alkenes and Alkynes – Preparation by elimination of alcohols, alkyl halides and quaternary ammonium hydroxides, Saytzeff and Hofmann rules; Reactions – electrophilic addition of X_2, HX, HOX, H_2O (X = halogen), ozonolysis, epoxidation and oxidation with $KMnO_4$, OsO_4 (stereochemistry of addition excluded).

Markownikoff's and anti-Markownikoff's additions; Hydroboration; Oxymercuration – demercuration, reduction of alkenes and alkynes (H_2/Lindler catalyst and Na in liquid NH_3), metal acetylides.

Alkyl halides – Preparation from alcohols; Formation of Grignard reagents and their synthetic applications for the preparation of alkanes, alcohols, aldehydes, ketones and acids; S_N1 and S_N2 reactions (preliminary concept).

Alcohols – Preparation from carbonyl compounds and esters. Reaction – dehydration, oxidation, esterification, reaction with sodium, $ZnCl_2$ / HCl, phosphorous halides.

Ethers – Preparation by Williamson's synthesis; Cleavage with HCl and HI.

Aldehydes and Ketones – Preparation from esters, acid chlorides, gem-dihalides, Ca-salt of carboxylic acids. Reaction – Nucleophilic addition with HCN, hydrazine, hydroxyl amines, semi carbazides, alcohols; Aldol condensation, Clemmensen and Wolff-Kishner reduction, haloform, Cannizzaro and Wittig reactions.

Carboxylic Acids – Hydrolysis of esters (mechanism excluded) and cyanides; Hunsdicker and HVZ reactions.

Aliphatic Amines – Preparation from nitro, cyano and amido compounds. Distinction of 1º, 2º and 3º amines (Hinsberg method); Reaction with HNO_2; Carbyl amine reaction.

Aromatic Compounds

Benzene – Kekule structure, aromaticity and Hückel rule. Electrophilic substitution – halogenation, sulfonation, nitration, Friedel Crafts reaction, ozonolysis. Directive influence of substituents in monosubstituted benzenes.

Amines – Preparation from reduction of nitro compounds; Formation of diazonium salts and their stability; Replacement of diazonium group with H, OH, X (halogen), CN and NO_2, diazocoupling and reduction.

Haloarenes – Nucleophilic substitution, cine substitution (excluding mechanism).
Phenols – halogenation, sulfonation, nitration, Reimer-Tiemann and Kolbe reactions.

Aromatic Aldehydes – Preparation by Gattermann, Gattermann – Koch, Rosenmund and Stephen's method. Reactions – Perkin, Benzoin and Cannizzaro.

Application Oriented chemistry
Main ingredients, their chemical natures (structures excluded) and their side effects, if any, of common antiseptics, analgesics, antacids, vitamin-C.

Introduction to Bio-molecules
Carbohydrates – Pentoses and hexoses. Distinctive chemical reactions of glucose.
Aminoacids – glycine, alanine, aspartic acid, cysteine (structures). Zwitterion structures of amino acids, peptide bond.
ADP and ATP – structures and role in bioenergetics; Nucleic acids – DNA and RNA skeleton structures. Names of essential elements in biological system.

Principles of qualitative analysis

Detection of water soluble noninterfaring Acid and Basic Radicals by dry and wet tests from among :

(a) Acid Radicals : Cl^-, S^{2-}, SO_4^{2-}, NO^-_3, CO_3^{2-}

(b) Basic Radicals: Cu^{2+}, Al^{3+}, Fe^{3+}, Fe^{2+}, Zn^{2+}, Ca^{2+}, Mg^{2+}, Na^+, NH_4^+

Detection of special elements (N, Cl, Br, I and S) in organic compounds by chemical tests. Identification of functional groups in : phenols, aromatic amines, aldehydes, ketones and carboxylic acids.