

Chemistry Syllabus

There is one paper of 3 hours duration divided into 2 parts.

Part I (20 marks) consists of compulsory short answer questions, testing knowledge, application and skills relating to elementary/fundamental aspects of the entire syllabus.

Part II (50 marks) is divided into 3 Sections, A, B and C. You are required to answer two out of three questions from Section A (each carrying 10 marks), two out of three questions from Section B (each carrying 5 marks) and two out of three questions from Section C (each carrying 10 marks). Therefore, a total of six questions are to be answered in Part II.

SECTION A

1. Some Basic Concepts of Chemistry

(i) Precision and Accuracy

(ii) Dimensional Analysis

(iii) The concept of atoms having fixed properties in explaining the laws of chemical combination.

(iv) Atomic and isotopic masses.

(v) Chemical equivalents, volumetric calculations in terms of normality. $C = 12.00$ should be taken as a standard for expressing atomic masses.

(vi) Relative molecular mass and mole. The following methods may be considered for the determination of relative molecular masses for the gases: the molar volume method; Victor Meyer's method (experimental details not required).

(vii) Chemical reaction - Stoichiometric calculations based on mass-mass, mass-volume and volume-volume relationships.

2. Atomic Structure

(i) Electrons, Protons and Neutrons as fundamental particles, their charges and masses.

(ii) Rutherford's nuclear model based on the scattering experiment.

(iii) Bohr's atomic model.

(iv) Atomic structure: wave mechanical model- a simple mathematical treatment. Quantum numbers; shape, size and orientation of s, p and d orbitals only (No derivation).

Hund's rule of maximum multiplicity. Pauli's exclusion principle, Aufbau principle, electronic configuration of elements in terms of s, p, d, f subshells.

3. Periodic Table

(i) Atomic number (Proton number) as the basis for classification of the elements in the Periodic Table. IUPAC nomenclature for elements with $Z > 100$.

(ii) Extra nuclear structure as the basis of periodicity. Some idea of the following: ionisation enthalpy, electron gain enthalpy, atomic radius, atomic volume, electronegativity, etc must be given. The periodicity of electronic structure leading to the periodicity of elements e.g. the relative ease of ionisation of elements.

(iii) Periodicity of elements with reference to s, p, d and f block elements.

4. Chemical Bonding

Kossel-Lewis approach to Chemical Bonding.

Electrovalent Bond

(i) Electrovalent or ionic bond e.g formation of NaCl, Li_2O , MgO, CaO, MgF_2 , and Na_2S .

(ii) Factors influencing the formation of ionic bond, e.g electron gain enthalpy, ionisation enthalpy, lattice energy and electronegativity.

(iii) The relation between the ionic bonding and Periodic Table.

(iv) Variable electrovalency and its causes.

Covalent Bond

(i) Covalent bond, sigma and pi bonds e.g. formation of ammonia, nitrogen, ethene, ethyne, and carbon dioxide. Resonance.

(ii) Variable valency: chlorine exhibits the valency of 1,3,5 & 7.

(iii) Deviation from Octet rule and Fajan's rules.

(iv) Co-ordinate or dative covalent bond, e.g. formation of oxy-acids of chlorine.

(v) Hydrogen bonding: its essential requirements, the examples of hydrogen fluoride, water (ice), alcohol, etc may be considered.

(vi) Metallic bonding, van der Waals' forces.

(vii) Valence Shell Electron Pair Repulsion Theory; Hybridization and shapes of molecules: hybridization involving s, p and d orbitals only; sigma and pi bonds.

(viii) Molecular orbital theory, Qualitative treatment of homonuclear diatomic molecules of first two periods (Hydrogen to Neon). Energy level diagrams, bonding, antibonding molecular orbitals, bond order, paramagnetism of O_2 molecule. Relative stabilities of O_2 , O_2^- , O_2^{2-} , O_2^+ and N_2 , N_2^+ , N_2^- , N_2^{2-} .

5. The Gaseous State

- (i) The gas laws, kinetic theory treated qualitatively.
- (ii) $PV = nRT$ or $PV = (w/M)RT$ and the application of this equation of state.
- (iii) Non ideal behaviour of gases and van der Waals' equation.
- (iv) Dalton's law, the Avogadro's constant, the mole, Graham's law of diffusion, simple numerical problems on the above.

6. Surface Chemistry

- (i) Adsorption
- (ii) Colloidal State: Preparation and properties of colloids, both lyophilic and lyophobic colloids. Precipitation as evidence that the colloidal particles are charged. Idea of gold number is required, but application of gold number is not required. The importance of large surface area in adsorption should also be appreciated.
- (iii) Chromatography

7. Chemical Kinetics

Rate of a chemical reaction, basic idea of order and molecularity of a reaction.

8. Chemical Energetics

- (i) Introduction.
- (ii) First law of Thermodynamics and its mathematical statement.
- (iii) Ideas about Heat, Work and Energy.
- (iv) Second law of thermodynamics - Reversible and irreversible changes, isobaric, isochoric adiabatic processes; Entropy, Free Energy. Spontaneity of a chemical change. $\Delta G^\circ = -2.303 RT \log K_{eq}$.
- (v) Third Law of Thermodynamics - statement only.
- (vi) Thermochemistry:
 - (a) Definitions.

- (b) Constancy in the heat of neutralisation.
- (c) Calorific value of a fuel.
- (d) Hess's law of constant heat summation - simple problems based on the above definitions and concepts.

SECTION B

9. Study of Representative Elements: Group 1, 2, 13, 14, 15

The following should be included: a) Occurrence, (b) Physical State, (c) Electronic Configuration, (d) Atomic and Ionic radii, (e) Common oxidation state, (f) Electropositive / Electronegative character, (g) Ionisation enthalpy, (h) Reducing/oxidising nature, (i) Distinctive behaviour of first member of each group (namely Lithium, Beryllium, Boron, Carbon, Nitrogen), (j) Nature of oxides, hydroxides, hydrides, carbonates, nitrates, chlorides, sulphates, wherever applicable.

10. Preparation, properties and uses of Compounds of Groups 1, 2, 13, 14, 15

Only brief qualitative treatment is required for preparation. Main emphasis must be given to the chemistry of preparation, chemical properties and uses of the given compounds. Biological importance of magnesium, sodium, calcium and potassium.

Group 1: Sodium chloride, Sodium hydroxide, Sodium carbonate, Sodium bicarbonate, Sodium thiosulphate; Group 2: Magnesium chloride hexahydrate, Calcium oxide, Plaster of Paris, Cement; Group 13: Borax, Borax Bead Test, Boric acid, Alums; Group 14: Carbon monoxide, Carbon dioxide, Silicon dioxide, Silicon carbide, Silicones; Group 15: Oxides of nitrogen, Phosphorus trichloride, Phosphorus pentachloride, Oxoacids of phosphorus.

11. Redox Reactions

Concept of oxidation and reduction in terms of oxygen, hydrogen, electrons.

Redox reactions - examples.

Oxidation number: Rules for calculation, simple calculations of oxidation state in molecules and ions

Oxidation and reduction in terms of change in oxidation number.

Balancing of redox reactions in acidic and basic medium by oxidation number and ion-electron method.

SECTION C

12. Introduction to Organic Chemistry

- (i) The unique nature of carbon atom and catenation.
- (ii) Classification of organic compounds and homologous series.
- (iii) Detection of carbon, hydrogen, sulphur, nitrogen and halogen.
- (iv) Estimation of carbon, hydrogen, nitrogen, halogens, sulphur and phosphorous.

13. Isomerism

Definition. Classification of isomerism.

- (i) Structural Isomerism.
- (ii) Stereo Isomerism.
 - (a) Geometric isomerism (cis and trans only).
 - (b) Optical isomerism

14. Types of Chemical Reactions and their Mechanisms

- (i) Substitution, addition and elimination reactions.
- (ii) Homolytic and heterolytic fission.
- (iii) Electrophiles and nucleophiles.
- (iv) Inductive, mesomeric, electromeric effects and hyperconjugation.
- (v) Free radicals and polar mechanisms (in terms of fission of the bonds and formation of the new bonds) including S_N1 , S_N2 , E_1 and E_2 mechanisms.

15. Aliphatic and Aromatic Hydrocarbons

- (i) Alkanes: General methods of preparation, Properties of alkanes.
- (ii) Alkenes: general methods of preparation and properties of alkenes.
- (iii) Alkynes: methods of preparation (including manufacture), properties and uses of ethyne.
- (iv) Benzene: Coal tar as an important source of aromatic compounds; preparation of benzene from sodium benzoate, properties and uses of benzene; resonance model of benzene; directive influence of substituents in the benzene ring.

16. Applications of Chemicals

- (i) In medicine: antipyretics, analgesics, tranquillisers, antiseptics, disinfectants, anti-microbials, anti-fertility drugs, antihistamines, antibiotics, antacids.

(ii) Soaps and Detergents: classification, structure and some important examples.

17. Environmental Chemistry

(i) Energy: Non-renewable and renewable sources, use of diesel and petrol in trains buses, cars and other vehicles, use of LPG, use of CNG and their role in pollution control.

Future sources of energy - hydrogen, alcohol, fuel cells and bio-fuels. Brief explanation.

Methods of saving energy in homes and institutions - use of energy saving bulbs, solar cooker, bio-gas pipeline.

(ii) Pollution: Environmental pollution: atmospheric pollution and water pollution.