

## SECTION 2: CHEMISTRY

### 2.1. Content List for Chemistry

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3	Gases
4	Liquids
5	Solids
6	Chemical Equilibrium
7	Reaction Kinetics
8	Thermo-chemistry and Energetics of chemical reactions
9	Electrochemistry
10	Chemical bonding
11	S and p block elements
12	Transition Elements
13	Fundamental principles of organic chemistry
14	Chemistry of Hydrocarbons
15	Alkyl halides
16	Alcohols & phenols
17	Aldehydes and Ketones
18	Carboxylic acid
19	Macromolecules

## 2.2. Subtopics & Learning Objectives

### 1- INTRODUCTION OF FUNDAMENTAL CONCEPTS OF CHEMISTRY

#### SUBTOPICS

- Atomic mass
- Empirical formula
- Molecular formula
- Concept of mole
- Construction of mole ratios as conversion factors in stoichiometry calculations
- Avogadro's number
- Important assumptions of stoichiometric calculations
- Stoichiometry
- Limiting reactant
- Percentage yield

#### LEARNING OBJECTIVES

- 1.1. Construct mole ratios from balanced equations for use as conversion factors in stoichiometric problems.
- 1.2. Perform stoichiometric calculations with balanced equations using moles, representative particles, masses and volumes of gases (at STP).
- 1.3. Explain the limiting reagent in a reaction,
- 1.4. Calculate the maximum number of product(s) produced and the amount of any un-reacted excess reagent.
- 1.5. Given information from which any two of the following may be determined, calculate the third: theoretical yield, actual yield, percentage yield.
- 1.6. Calculate the theoretical yield and the percent yield when given the balanced equation, the amounts of reactants and the actual yield

### 2- ATOMIC STRUCTURE

#### SUBTOPICS

- Concept of orbital's
- Electronic configuration
- Discovery and properties of proton (positive rays)
- Quantum numbers
- Shapes of orbital's

#### LEARNING OBJECTIVES

- 2.1. Describe discovery and properties of proton (positive rays)
- 2.2. Define photon as a unit of radiation energy.
- 2.3. Describe the concept of orbitals.
- 2.4. Distinguish among principle energy levels, energy sub-levels, and atomic orbitals.
- 2.5. Describe the general shapes of s, p, and orbitals.
- 2.6. Describe the hydrogen atom using the quantum theory.
- 2.7. Use the Aufbau Principle, the Pauli Exclusion Principle, and Hund's Rule to write the electronic configuration of the atoms.
- 2.8. Write electronic configuration of atoms.

### 3-GASES

#### SUBTOPICS

- Properties of gases
- Gas laws
- Boyle's law
- Charles's law
- General gas equation
- Kinetic molecular theory of gases
- Ideal gas equation

#### LEARNING OBJECTIVES

- 3.1. List the postulates of kinetic molecular theory.
- 3.2. Describe the motion of particles of a gas according to kinetic theory.
- 3.3. State the values of standard temperature and pressure (STP).
- 3.4. Describe the effect of change in pressure on the volume of gas.
- 3.5. Describe the effect of change in temperature on the volume of gas.
- 3.6. Explain the significance of absolute zero, giving its value in degree Celsius and Kelvin.
- 3.7. Derive ideal gas equation using Boyle's, Charles' and Avogadro's law.
- 3.8. Explain the significance and different units of ideal gas constant.
- 3.9. Distinguish between real and ideal gases

### 4- LIQUIDS

#### SUBTOPICS

- Properties of liquids
- Intermolecular forces
- Hydrogen bonding
- Vapor pressure
- Boiling point and external pressure

#### LEARNING OBJECTIVES

- 4.1. Describe simple properties of liquids e.g. diffusion, compression, expansion, motion of molecules, spaces between them, intermolecular forces and kinetic energy based on kinetic molecular theory.
- 4.2. Explain physical properties of liquids such as evaporation, vapor pressure, boiling point.
- 4.3. Describe the hydrogen bonding in H<sub>2</sub>O, NH<sub>3</sub> and HF molecules.
- 4.4. Anomalous behavior of water when its density shows maximum at 4 degree centigrade

### 5- SOLIDS

#### SUBTOPICS

- Introduction
- Types of solids
- Ionic solids
- Molecular solids
- Crystal lattice

#### LEARNING OBJECTIVES

- 5.1. Describe crystal line solids.
- 5.2. Name three factors that affect the shape of an ionic crystal.
- 5.3. Give a brief description of ionic and molecular solids.
- 5.4. Describe crystal lattice.
- 5.5. Define lattice energy.

## 6- CHEMICAL EQUILIBRIUM

### SUBTOPICS

- Reversible and irreversible reactions
- State of chemical equilibrium
- Equilibrium constant expression for important reaction
- Applications of equilibrium constant
- Solubility product
- The Le Chatelier's principle
- Synthesis of ammonia by Haber's Process
- Common ion effect
- Buffer solutions
- Equilibrium of slightly soluble ionic compounds (solubility product)

### LEARNING OBJECTIVES

- 6.1. Define chemical equilibrium in terms of a reversible reaction.
- 6.2. Write both forward and reverse reactions and describe their macroscopic characteristics of each.
- 6.3. State Le Chatelier's Principle and be able to apply it to systems in equilibrium with changes in concentration, pressure, temperature, or the addition of catalyst.
- 6.4. Define and explain solubility product.
- 6.5. Define and explain the common ion effect giving suitable examples.
- 6.6. Describe buffer solutions and explain types of buffers.
- 6.7. Explain synthesis of ammonia by Haber's Process.

## 7- REACTION KINETICS

### SUBTOPICS

- Rate of reaction
- Determination of the rate of a chemical reaction
- Factors affecting rate of reaction
- Specific rate constant or velocity constant
- Units of rate constant
- Order of reaction and its determination

### LEARNING OBJECTIVES

- 7.1. Define chemical kinetics.
- 7.2. Explain the terms rate of reaction, rate equation, order of reaction, rate constant and rate determining step.
- 7.3. Explain qualitatively factors affecting rate of reaction.
- 7.4. Given the order with respect to each reactant, write the rate law for the reaction.
- 7.5. Explain the meaning of the terms 'activation energy' and 'activated complex'.
- 7.6. Relate the ideas of activation energy and the activated complex to the rate of a reaction.
- 7.7. Explain effects of concentration, temperature and surface area on reaction rates.
- 7.8. Describe the role of the rate constant in the theoretical determination of reaction rate.

## 8- THERMOCHEMISTRY & ENERGETICS OF CHEMICAL REACTIONS

### SUBTOPICS

- System, surrounding and state function
- Definitions of terms used in thermodynamics
- Standard states and standard enthalpy changes
- Energy in chemical reactions
- First Law of thermodynamics
- Sign of  $\Delta H$
- Enthalpy of a reaction
- Hess's law of constant heat summation

### LEARNING OBJECTIVES

- 8.1. Define thermodynamics.
- 8.2. Classify reactions as exothermic or endothermic.
- 8.3. Define the terms system, surrounding, boundary, state function, heat, heat capacity, internal energy, work done and enthalpy of a substance.
- 8.4. Name and define the units of thermal energy.
- 8.5. Explain the first law of thermodynamics for energy conservation.
- 8.6. Apply Hess's Law to construct simple energy cycles.
- 8.7. Describe enthalpy of a reaction.

### SUBTOPICS

- Oxidation number or state
- Explanation of electrolysis
- Electrode potential
- Balancing of redox equations by ion-electron method
- Balancing redox equations by oxidation number change method

## 9- ELECTROCHEMISTRY

### LEARNING OBJECTIVES

- 9.1. Give the characteristics of a redox reaction.
- 9.2. Define oxidation and reduction in terms of a change in oxidation number.
- 9.3. Use the oxidation-number change method to identify atoms being oxidized or reduced in redox reactions.
- 9.4. Define cathode, anode, electrode potential and S.H.E (Standard Hydrogen Electrode).
- 9.5. Define the standard electrode potential of an electrode.
- 9.6. Use the ion-electron method/oxidation number method to balance chemical equations.

### SUBTOPICS

- Energetic of bond formation
- Atomic sizes
- Atomic radii
- Ionic radii
- Covalent radii
- Ionization energy
- Electron affinity
- Electro negativity
- Bond energy
- Bond length
- Types of bonds
- Electrovalent or Ionic Bond
- Covalent bond
- Co-ordinate or dative covalent bond
- Ionic character of covalent bond
- Sigma and Pi bond
- Hybridization
- $sp^3$ -Hybridization
- $sp^2$ -Hybridization
- $sp$ -hybridization
- The Valence Shell Electron Pair Repulsion theory
- Postulates of VSEPR theory
- Applications of VSEPR theory

## 10- CHEMICAL BONDING

### LEARNING OBJECTIVES

- 10.1. Use VSEPR theory to describe the shapes of molecules.
- 10.2. Describe the features of sigma and pi bonds.
- 10.3. Describe the shapes of simple molecules using orbital hybridization.
- 10.4. Determine the shapes of some molecules from the number of bonded pairs and lone pairs of electrons around the central atom.
- 10.5. Predict the molecular polarity from the shapes of molecules.
- 10.6. Explain what is meant by the term ionic character of a covalent bond.
- 10.7. Describe how knowledge of molecular polarity can be used to explain some physical and chemical properties of molecules.
- 10.8. Define bond energies and explain how they can be used to compare bonds strengths of different chemical bonds.
- 10.9. Define and explain the terms atomic radii, ionic radii, covalent radii, ionization energy, electron affinity, electro negativity, bond energy and bond length.

## 11- S AND P BLOCK ELEMENTS

### SUBTOPICS

- Electronic configuration
- Chemical properties of s-block elements
- Group1 Elements (Alkali Metals)
- Atomic and Physical properties
- Trends in reactivity
- Group2 Elements (Alkaline earth metals)
- Trends in reactivity
- Physical and chemical properties
- Group trends: atomic radii, ionic radii, electro negativity, ionization potential, electropositivity or metallic character, melting and boiling points

### LEARNING OBJECTIVES

- 11.1. Recognize the demarcation of the periodic table into s block, p block, d block, and f block.
- 11.2. Describe how physical properties like atomic radius, ionization energy, electro negativity, electrical conductivity and melting and boiling points of elements change within a group and within a period in the periodic table.
- 11.3. Describe reactions of Group I elements with water, oxygen and chlorine.
- 11.4. Describe reactions of Group II elements with water, oxygen and nitrogen.
- 11.5. Describe reactions of Group III elements with water, oxygen and chlorine.

## 12- TRANSITION ELEMENTS

### SUBTOPICS

- General characteristics

### LEARNING OBJECTIVES

- 12.1. Describe electronic structures of elements and ions of d-block elements.

## 13- FUNDAMENTAL PRICIPLES OF ORGANIC CHEMISTRY

### SUBTOPICS

- Classification of organic compound
- Isomerism

### LEARNING OBJECTIVES

- 13.1. Define organic chemistry and organic compounds.
- 13.2. Classify organic compounds on structural basis.
- 13.3. Define functional group.
- 13.4. Explain isomerism and its types.

## 14- CHEMISTRY OF HYDROCARBONS

### SUBTOPICS

- Open chain and closed chain hydrocarbons
- Nomenclature of alkanes, alkenes and alkynes
- Benzene: Properties, structure, modern representation, reactions, resonance method, electrophilic substitution,
- The molecular orbital treatment of benzene.

### LEARNING OBJECTIVES

- 14.1. Classify hydrocarbons as aliphatic and aromatic.
- 14.2. Describe nomenclature of alkanes.
- 14.3. Define free radical initiation, propagation and termination.
- 14.4. Describe the mechanism of free radical substitution in alkanes exemplified by methane and ethane.
- 14.5. Explain the IUPAC nomenclature of alkenes.
- 14.6. Explain the shape of ethane molecule in terms of sigma and pi C-C bonds.
- 14.7. Describe the structure and reactivity of alkenes as exemplified by ethane.
- 14.8. Define and explain with suitable examples the terms isomerism and structural isomerism.
- 14.9. Explain dehydration of alcohols and dehydrohalogenation of RX for the preparation of ethane.
- 14.10. Describe the chemistry of alkenes by the following reactions of ethene: Hydrogenation, hydrohalogenation, hydration, halogenation, halohydrate, polymerization.
- 14.11. Explain the shape of the benzene molecule (molecular orbital treatment).
- 14.12. Define resonance, resonance energy and relative stability.
- 14.13. Compare the reactivity of benzene with alkanes and alkenes.
- 14.14. Describe addition reactions of benzene and methylbenzene.
- 14.15. Describe the mechanism of electrophilic substitution in benzene.
- 14.16. Discuss chemistry of benzene and methylbenzene by nitration, sulphonation, halogenation, Friedel Craft's alkylation and acylation.
- 14.17. Apply the knowledge of positions of substituents in the electrophilic substitution of benzene.
- 14.18. Use the IUPAC naming system for alkynes.
- 14.19. Compare the reactivity of alkynes with alkanes, alkenes and arenes.
- 14.20. Describe the preparation of alkynes using elimination reactions.
- 14.21. Describe acidity of alkynes.
- 14.22. Discuss chemistry of alkynes by hydrogenation, hydrohalogenation, and hydration.
- 14.23. Describe and differentiate between substitution and addition reactions.

## 15- ALKYL HALIDES

### SUBTOPICS

- Classification of alkyl halides
- Nomenclature
- Reactions
- Mechanism of nucleophilic substitution reaction SN<sub>1</sub>, SN<sub>2</sub>, E<sub>1</sub> and E<sub>2</sub> reaction

### LEARNING OBJECTIVES

- 15.1. Name alkyl halides using IUPAC system.
- 15.2. Discuss the structure and reactivity of RX.
- 15.3. Describe the mechanism and types of nucleophilic substitution reactions.
- 15.4. Describe the mechanism and types of elimination reactions.

## 16- ALCOHOLS AND PHENOLS

### SUBTOPICS

- Alcohols:
  - Classification: Primary, secondary and tertiary alcohols
  - Nomenclature
  - Reactivity
- Phenols:
  - Physical properties
  - Nomenclature
  - Acidity
  - Reactivity

### LEARNING OBJECTIVES

- 16.1. Explain nomenclature and structure of alcohols.
- 16.2. Explain the reactivity of alcohols.
- 16.3. Describe the chemistry of alcohols by preparation of ethers and esters.
- 16.4. Explain the nomenclature and structure of phenols.
- 16.5. Discuss the reactivity of phenol and their chemistry by electrophilic aromatic substitution.
- 16.6. Differentiate between an alcohol and phenol.

## 17- ALDEHYDES & KETONES

### SUBTOPICS

- Nomenclature
- Preparation
- Reactions

### LEARNING OBJECTIVES

- 17.1. Explain nomenclature and structure of aldehydes and ketones.
- 17.2. Discuss the preparation of aldehydes and ketones.
- 17.3. Describe reactivity of aldehydes and ketones and their comparison.
- 17.4. Describe acid and base catalyzed nucleophilic addition reactions of aldehydes and ketones.
- 17.5. Discuss the chemistry of aldehydes and ketones by their reduction to alcohols.
- 17.6. Describe oxidation reactions of aldehydes and ketones.

## 18- CARBOXYLIC ACIDS

### SUBTOPICS

- Nomenclature
- Classification
- Physical properties
- Preparations of carboxylic acids
- Reactivity

### LEARNING OBJECTIVES

- 18.1. Describe nomenclature, chemistry and preparation of carboxylic acids.
- 18.2. Discuss reactivity of carboxylic acids.
- 18.3. Describe the chemistry of carboxylic acids by conversion to carboxylic acid derivatives: acyl halides, acid anhydrides, esters, amides and reactions involving inter conversion of these.

## 19- MACRO MOLECULES

### SUBTOPICS

- Proteins
- Enzymes

### LEARNING OBJECTIVES

- 19.1. Explain the basis of classification and structure-function relationship of proteins.
- 19.2. Describe the role of various proteins in maintaining body functions and their nutritional importance.
- 19.3. Describe the role of enzymes as biocatalysts.