SECTION 2: CHEMISTRY

2.1. Content List for Chemistry

#	Content
1	Introduction to fundamental concepts of chemistry
2	Atomic Structure
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 OBJETIVES 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 H2O, NH3 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 EQUILIBIRIUM	**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 OBJETIVES 6.1. Define chemical equilibrium in terms of a reversible reaction. 6.2. Write both forward and reverse reactions and describe them acroscopic 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 ΔH • 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.
9- ELECTROCHEMISTRY	**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
	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 oxidize do 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.
10- CHEMICAL BONDING	**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

	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, electro-positivity 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 l 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, halohydration, 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, Friedal 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 SN1, SN2, E1 and E2 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 an hydrides, 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.