NUMS MDCAT CURRICULUM

CHEMISTRY

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INTRODUCTION TO FUNDAMENTAL CONCEPTS OF CHEMISTRY

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- Molecular formula
- Concept of mole
- Construction of mole ratios as conversion factors in stoichiometry calculations
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- Important assumptions of stoichiometric calculations
- Stoichiometry
- Limiting reactant
- Percentage yield

Learning Outcomes

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

ATOMIC STRUCTURE

- Concept of orbitals
- Electronic configuration
- Discovery of electron
- Properties of cathode rays
- Discovery of proton (positive Rays)
- Properties of positive Rays
- Discovery of neutron
- Properties of neutron
- Rutherford's model of atom (Discovery of Nucleus)
- Spectrum
- Hydrogen spectrum
- X-rays and atomic number
- Quantum numbers
- Shapes of orbitals
- Electronic configuration of elements

Learning Outcomes

- Relate energy equation (for electron) to frequency, wavelength and wave number of radiations emitted or absorbed by electron.
- Explain production, properties, types and uses of X-rays. (Understanding)
- Define photon as a unit of radiation energy. (Remembering)
- Describe the concept of orbitals. (Understanding)
- Distinguish among principal energy levels, energy sub levels, and atomic orbitals. (Understanding)
- Describe the general shapes of s, p, and d orbitals. (Understanding)
- Describe the hydrogen atom using the quantum theory. (Understanding)
- Use the Aufbau Principle, the Pauli Exclusion Principle, and Hund's Rule to write the electronic configuration of the elements. (Applying)
- Describe the orbitals of hydrogen atom in order of increasing energy. (Understanding)
- Write electron configuration of atoms. (Applying)

- Describe discovery and properties of cathode rays, protons and neutrons. (understanding)

GASES

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

Learning Outcomes

- List the postulates of Kinetic Molecular Theory. (Remembering)
- Describe the motion of particles of a gas according to Kinetic Theory. (Applying)
- State the values of standard temperature and pressure (STP). (Remembering)
- Describe the effect of change in pressure on the volume of gas. (Applying)
- Describe the effect of change in temperature on the volume of gas. (Applying)
- Explain the significance of absolute zero, giving its value in degree Celsius and Kelvin. (Understanding)
- Derive ideal gas equation using Boyle's, Charles' and Avogadro's law. (Understanding)
- Explain the significance and different units of ideal gas constant. (Understanding)
- Distinguish between real and ideal gases. (Understanding)

LIQUIDS

- Properties of liquids
- Intermolecular forces (Van DER WAAL's equation)
- Dipole-dipole forces
- Intermolecular forces
- Dipole-induced dipole forces
- Vapor pressure
- Boiling point and external pressure

Learning Outcomes

- 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. (Understanding)
- Explain applications of dipole-dipole forces, hydrogen bonding and London forces. (Applying)
- Explain physical properties of liquids such as evaporation, vapor pressure, boiling point, viscosity and surface tension. (Understanding)
- Use the concept of hydrogen bonding to explain the following properties of water: high surface tension, high specific heat, low vapor pressure, high heat of vaporization, and high boiling point
- Anomalous behavior of water when its density shows maximum at 4 degree centigrade (Applying)

SOLIDS

- Introduction
- Types of solids
- Crystalline solids
- Properties of crystalline solids
- Geometrical shape
- Melting points
- Crystal lattice
- Unit cell
- Crystal and their classification
- Classification of solids
- Ionic solids
- Molecular solids

Learning Outcomes

- Describe simple properties of solids e.g., diffusion, compression, expansion, motion of molecules, spaces between them, intermolecular forces and kinetic energy based on kinetic molecular theory. (Understanding)
- Describe crystalline solids. (Understanding)
- Describe properties of crystalline solids like geometrical shape, melting point, allotropy and transition temperature. (Understanding)
- Explain the significance of the unit cell to the shape of the crystal using NaCl as an example. (Applying)
- Name three factors that affect the shape of an ionic crystal. (Understanding)
- Define lattice energy. (Remembering)

CHEMICAL EQUILIBRIUM

- 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
- Applications of chemical equilibrium in industry
- Synthesis of ammonia by Haber's Process
- Common Ion effect
- Buffer solutions
- Equilibria of slightly soluble Ionic compounds (Solubility product)

Learning Outcomes

- Define chemical equilibrium in terms of a reversible reaction. (Remembering)
- Write both forward and reverse reactions and describe the macroscopic characteristics of each. (Understanding)
- Determine if the reactants or products are favored in a chemical reaction, given the equilibrium constant. (Analyzing)
- 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. (Applying)
- Explain industrial applications of Le Chatelier's Principle using Haber's process as an example. (Analyzing)
- Define and explain solubility product. (Understanding)
- Define and explain common ion effect giving suitable examples. (Applying)
- Describe buffer solutions and explain types of buffers.

REACTION KINETICS

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

Learning Outcomes

- Define chemical kinetics. (Remembering)
- Explain and use the terms rate of reaction, rate equation, order of reaction, rate constant and rate determining step. (Understanding)
- Explain qualitatively factors affecting rate of reaction. (Applying)
- Given the order with respect to each reactant, write the rate law for the reaction. (Applying)
- Explain what is meant by the terms activation energy and activated complex. (Understanding)
- Relate the ideas of activation energy and the activated complex to the rate of a reaction. (Applying)
- Explain effects of concentration, temperature and surface area on reaction rates. (Applying)
- Describe the role of the rate constant in the theoretical determination of reaction rate. (Applying)

THERMOCHEMISTRY AND ENERGETICS OF CHEMICAL REACTIONS

- 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
- Enthalpy of formation
- Enthalpy of formation
- Enthalpy of formation
- Heat of formation
- Hess's law of constant heat summation
- Born-Haber cycle

Learning Outcomes

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

ELECTROCHEMISTRY

- Oxidative number or state
- Oxidative state and balancing of Redox Equations
- Explanation of electrolysis
- Electrode potential
- Balancing of redox equations by ion-electron method
- Balancing redox equations by oxidation number change method

Learning Outcomes

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

CHEMICAL BONDING

- Energetics of bond formation
- Atomic sizes
- Atomic radii
- Ionic radii
- Covalent radii
- Ionization energy
- Electron affinity
- Electronegativity
- Bond Energy
- Bond Length
- Types of Bonds
- Energetics of Bond Formation
- 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
- Shapes of simple molecules
- The Valence Shell Electron Pair Repulsion theory
- Postulates of VESPR theory
- Applications of VSEPR theory

Learning Outcomes

- Use VESPER theory to describe the shapes of molecules. (Applying)
- Describe the features of sigma and pi bonds. (Understanding)
- Describe the shapes of simple molecules using orbital hybridization. (Applying)

- Determine the shapes of some molecules from the number of bonded pairs and lone pairs of electrons around the central atom. (Analyzing)
- Predict the molecular polarity from the shapes of molecules. (Applying)
- Explain what is meant by the term ionic character of a covalent bond. (Understanding)
- Describe how knowledge of molecular polarity can be used to explain some physical and chemical properties of molecules. (Analyzing)
- Define bond energies and explain how they can be used to compare bond strengths of different chemical bonds. (Analyzing)

S AND P BLOCK ELEMENTS

- Electronic configuration
- Chemical properties of S-block elements
- Group 1 Elements (Alkali Metals)
- Atomic and Physical properties
- Trends in reactivity
- Group 2 Elements (Alkaline earth metals)
- Trends in reactivity
- Physical and Chemical properties, trend from metal to non-metal
- Group trends: atomic radii, ionic radii, electronegativity, ionization potential, electropositivity or metallic character, melting and boiling points

Learning Outcomes

- Recognize the demarcation of the periodic table into s block, p block, d block, and f block. (Understanding)
- Describe how physical properties like atomic radius, ionization energy, electronegativity, electrical conductivity and melting and boiling points of elements.
- Change within a group and within a period in the periodic table. (Analyzing)
- Describe reactions of Group I elements with water, oxygen and chlorine. (Applying)
- Describe reactions of Group II elements with water, oxygen and nitrogen.
- (Applying)
- Describe reactions of period 3 elements with water, oxygen and chlorine. (Applying)

TRANSITION ELEMENTS

- General characteristics

Learning Outcomes

- Describe electronic structures of elements and ions of d-block elements. (Applying)

FUNDAMENTAL PRINCIPLES OF ORGANIC CHEMISTRY

- Classification of organic compounds
- Petroleum: Refining, Reforming, Cracking
- Isomerism

Learning Outcomes

- Define organic chemistry and organic compounds. (Remembering)
- Classify organic compounds on structural basis. (Analyzing)
- Explain that organic compounds are also synthesized in the lab. (Understanding)
- Define functional groups (Remembering)
- Explain isomerism and its types.

CHEMISTRY OF HYDROCARBONS

- 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 Outcomes

- Classify hydrocarbons as aliphatic and aromatic. (Understanding)
- Describe nomenclature of alkanes. (Understanding)
- Define free radical initiation, propagation and termination. (Remembering)
- Describe the mechanism of free radical substitution in alkanes exemplified by methane and ethane. (Understanding)
- Explain the nomenclature of alkenes. (Understanding)
- Explain shape of ethene molecule in terms of sigma and pi C-C bonds. (Understanding)
- Describe the structure and reactivity of alkenes as exemplified by ethene. (Applying)
- Define and explain with suitable examples the terms isomerism and structural isomerism. (Remembering)
- Explain dehydration of alcohols and dehydrohalogenation of RX for the preparation of ethene. (Understanding)
- Describe the chemistry of alkenes by the following reactions of ethene:
- Hydrogenation, hydrohalogenation, hydration, halogenation, halohydration, polymerization. (Understanding)
- Use the IUPAC naming system for alkenes. (Applying)
- Explain the shape of benzene molecule (molecular orbital aspect). (Understanding)
- Define resonance, resonance energy and relative stability. (Understanding)
- Compare the reactivity of benzene with alkanes and alkenes. (Applying)
- Describe addition reactions of benzene and methyl benzene. (Applying)
- Describe the mechanism of electrophilic substitution in benzene. (Understanding)

- Discuss chemistry of benzene and methyl benzene by nitration, sulphonation, halogenation, Friedal Craft's alkylation and acylation. (Applying)
- Apply the knowledge of positions of substituents in the electrophilic substitution of benzene. (Applying)
- Use the IUPAC naming system for alkynes. (Applying)
- Compare the reactivity of alkynes with alkanes, alkenes and arenes. (Analyzing)
- Discuss the shape of alkynes in terms of sigma and pi C-C bonds. (Applying)
- Describe the preparation of alkynes using elimination reactions. (Applying)
- Describe acidity of alkynes. (Understanding)
- Discuss chemistry of alkynes by hydrogenation, hydrohalogenation, hydration. (Understanding)
- Describe and differentiate between substitution and addition reactions. (Understanding)

ALKYL HALIDES

- Classification of alkyl halides
- Nomenclature
- Reactions
- Mechanism of nucleophilic substitution reaction S_N1, S_N2, E1 and E2 reaction

Learning Outcomes

- Name alkyl halides using IUPAC system. (Applying)
- Discuss the structure and reactivity of RX. (Applying)
- Describe the mechanism and types of nucleophilic substitution reactions.
- (Understanding)
- Describe the mechanism and types of elimination reactions. (Understanding)

ALCOHOLS AND PHENOLS

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

Learning Outcomes

- Explain nomenclature and structure of alcohols. (Understanding)
- Explain reactivity of alcohols. (Understanding)
- Describe the chemistry of alcohols by preparation of ethers and esters (Applying)
- Explain the nomenclature and structure of phenols. (Applying)
- Discuss the reactivity of phenol and their chemistry by electrophilic aromatic substitution. (Applying)
- Differentiate between alcohol and phenol. (Understanding)

ALDEHYDES AND KETONES

- Nomenclature
- Preparation
- Reactions

Learning Outcomes

- Explain nomenclature and structure of aldehydes and ketones. (Applying)
- Discuss the preparation of aldehydes and ketones (Applying)
- Describe reactivity of aldehydes and ketones and their comparison. (Analyzing)
- Describe acid and base catalyzed nucleophilic addition reactions of aldehydes and ketones. (Applying)
- Discuss the chemistry of aldehydes and ketones by their reduction to alcohols, (Applying)
- Describe oxidation reactions of aldehydes and ketones. (Applying)

CARBOXYLIC ACIDS

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

Learning Outcomes

- Describe nomenclature, chemistry and preparation of carboxylic acids (Applying)
- Discuss reactivity of carboxylic acids. (Applying)
- Describe the chemistry of carboxylic acids by conversion to carboxylic acid derivatives: acyl halides, acid anhydrides, esters, amides and reactions involving interconversion of these. (Analyzing)
- Describe reactions of carboxylic acid derivatives. (Applying)

MACROMOLECULES

- Proteins
- Enzymes

Learning Outcomes

- Explain the basis of classification and structure-function relationship of proteins (Understanding)
- Describe the role of various proteins in maintaining body functions and their nutritional importance (Applying)
- Describe the role of enzyme as biocatalyst (Applying)