

Principles of General Chemistry | Table of Contents

Chapter 1: Essential Ideas

1.1 Chemistry: The Central Science

- Understand the aim, scope, and importance of chemistry
- Understand the domains of chemistry

1.2 The Scientific Method

- Understand how the scientific method works (5)

1.3 Matter, Mass, and Weight

- Compare and contrast properties of three states of matter (5)
- Distinguish between mass and weight (5)
- Understand the law of conservation of matter (40)

1.4 Atoms and Molecules

- Identify and describe atoms and molecules

1.5 Elements, Compounds, and Mixtures

- Classify matter as elements and compounds (5)
- Distinguish between heterogeneous and homogeneous mixtures (5)

1.6 Physical and Chemical Properties

- Understand physical properties and changes (5)
- Understand chemical properties and changes (5)
- Understand extensive and intensive properties of matter (5)
- Predict physical and chemical changes

1.7 Measurements

- Understand how to use metric and SI system of units names and abbreviations (5)
- Identify and use the SI units for length, volume, and mass (5)

1.8 Calculations using Measurements

- Perform density and specific gravity calculations (40)
- Survey quantities and units, understand measurements, and learn how to solve problems (5)
- Identify and use the SI units for temperature and time (40, 5)

1.9 Measurement Uncertainty

- Distinguish between accurate measurements and precise measurements (5)
- Use precision and trueness in calculations of relative error values and calculations of sample and relative standard deviation (5)

1.10 Significant Figures

- Determine the number of significant figures in a measured number (40, 5)
- Use significant figures in calculations (40)

1.11 Dimensional Analysis

- Solve single-step unit conversion problems using dimensional analysis (40)
- Solve multi-step unit conversion problems using dimensional analysis (40)

1.12 Temperature Conversions

- Use Fahrenheit, Celsius, and Kelvin temperature scales and convert between them (40)
-

Chapter 2: Atoms Molecules and Ions

2.1 Classical Atomic Theory

- Understand postulates of the Dalton's Atomic Theory
- Understand the laws of definite and multiple proportions

2.2 Modern Atomic Theory

- Describe modern atomic theory
- Identify and describe the subatomic particles that compose an atom (5)

2.3 Atomic Structure

- Determine the number of protons, electrons, and neutrons in the atom from the atomic and mass numbers (40, 5, 5)
- Calculate the average atomic mass of an element given isotopic mass and fractional abundance of each isotope

2.4 Isotopes

- Identify isotopes (5)
- Understand the natural abundances and distributions of the elements (5)

2.5 Chemical Symbols

- Read and interpret chemical symbols (5)

2.6 Chemical Formulas

- Read and write molecular formulas given atomic composition (5)
- Identify and interpret structural formulas (5)

2.7 The Periodic Table

- Understand the history of the periodic table (5)
- Understand the organization of the periodic table (5)

2.8 The Periodic Table: Interpretation and Identification

- Read and interpret an element block on the periodic table (40)
- Identify which group on the periodic table an element belongs to (6, 5)

2.9 Ionic Compounds

- Define ions and distinguish between monatomic ions and polyatomic ions (5)
- Describe properties of ionic compounds (5)

2.10 Molecular Compounds

- Understand the type of bonding that connects atoms in a molecular compound (5)
- Predict the type of bonding in a compound

2.11 Chemical Nomenclature: Ionic Compounds and Ions

- Write the formula of and name an ionic compound with a simple ion (5)
- Write the formula of and name a polyatomic ion or compound containing it (5)
- Write the formula of and name a metal ion with a variable charge (5)

2.12 Chemical Nomenclature: Molecular Compounds

- Write the formula of and name a molecular compound (5)

2.13 Chemical Nomenclature: Acids

- Write the formula of and name a binary acid
 - Write the formula of and name an oxyacid
-

Chapter 3: Substances and Solutions

3.1 Formula Mass

- Determine formula mass for covalent substances (40)
- Determine formula mass for ionic compounds (5)

3.2 The Mole: Definition and Use

- Understand the mole as a unit of measurement (5)

3.3 The Mole: Conversions to Grams

- Convert moles to grams and grams to moles for an element or a compound (40, 5)

3.4 The Mole: Conversions to Atoms and Molecules

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- Derive the number of atoms and molecules from the mass of a compound (40)

3.5 Empirical Formula

- Calculate percent composition of a compound given mass of components (40)
- Determine a compound's empirical formula from the masses of its elements (5)
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3.6 Molecular Formula

- Calculate percent composition given molecular formula (40)
- Derive a molecular formula for a compound given percent composition and molecular mass (5)

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- Derive moles and volumes from molar concentrations (40)

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- Calculate mass-volume percentage (40)
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4.1 Writing and Balancing Chemical Equations

- Understand how to represent a chemical reaction using an equation (40)
- Write and balance chemical equations (25)

4.2 Writing and Balancing Ionic Equations

- Write and balance chemical equations for ionic reactions (5)

4.3 Classifying Chemical Reactions: Precipitation

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- Write and balance chemical equations for acid-base reactions (5)

4.5 Classifying Chemical Reactions: Redox

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- Predict oxidation numbers (5)
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- Calculate the molar ratio between two substances given the balanced equation (40)
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- Calculate the amount of moles of a reactant required given moles of the other reactant(s) and a balanced equation (40)
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- Understand how to use specific heat in heat loss / gain calculations (40)

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- Calculate heat and related properties using bomb calorimetry (40)

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- Understand heat transfer between substances (40)

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-

Chapter 6: Electron Configuration and Properties of Elements

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- Understand standing waves

6.2 Bohr's Atomic theory

- Understand Bohr's atomic model (5)

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- Calculate the energy of electron transitions in a one-electron (bohr) system (40)

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- Understand the Heisenberg Uncertainty Principle
- Understand the quantum-mechanical model of an atom (5)

6.5 Quantum Numbers

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- Understand the Pauli Exclusion Principle (40, 5)

6.6 Electron Configurations

- Describe the electron configuration of an atom (5)
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- Understand magnetism and explore magnetic materials

6.7 Orbital Diagrams

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- Recognize variations in ionization energies using periodic trends (5)
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6.10 Paradoxes within the Classic Electromagnetic Theory

- Understand blackbody radiation
- Understand the photoelectric effect
- Understand how elements emit line spectra

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7.1 Ionic Bonding: Cations and Anions

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 - Determine the electronic structures of cations (5)
 - Determine the electronic structure of anions (5)
-

- Define the meaning and primary basis of qualitative analysis

7.2 Lattice Energy Calculations

- Understand ionic bond strength and lattice energy (5)
- Calculate lattice energy using the Born-Haber cycle (40)

7.3 Covalent Bonding: Understand the formation of covalent bonds

- Understand the formation of covalent bonds
- Compare and contrast pure and polar covalent bonds (5)

7.4 Covalent Bonding: Electronegativity and Bond Strength

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- Determine covalent bond strength

7.5 Lewis Structures

- Read lewis structures and draw a lewis structure for an atom (5)
- Understand how to draw lewis structures for covalent compounds using the octet rule (5)

7.6 Lewis Structures: Octet Rules

- Understand the octet rule and how to represent triple and double bonds when drawing lewis structures (5)
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- Write Lewis diagrams with octet rule exceptions (5)

7.7 Formal Charges and Resonance

- Calculate formal charge (5)
- Use formal charge to predict molecular structure (5)
- Recognize resonance forms

7.8 VSEPR Theory

- Understand how to determine molecular shape using the VSEPR theory (5)
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- Understand the role that molecular geometry plays in determining polarity of a compound (5)
- Determine the structure of multi-center molecules (5)

Chapter 8: Advanced Theories of Covalent Bonding

8.1 Valence Bond Theory

- Understand atomic orbital overlap (5)
- Identify sigma and pi bonds (5)

8.2 Hybridization

- Understand hybridization (5)
- Understand sp (1, 2, and 3) hybrid orbitals (5)
- Understand sp (1, 2, and 3) hybridization (5)

8.3 Hybrid Atomic Orbitals

- Understand sp³d and sp³d² hybridization (5)

8.4 Hybrid Atomic Orbitals: Assignments

- Understand the assignment of hybrid orbitals to central atoms (5)
- Understand orbital overlap in multiple bonds

8.5 Molecular Orbital Theory: Energy Diagrams

- Understand the molecular orbital theory (5)
- Understand molecular orbital energy diagrams (5)

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- Calculate bond order (5)
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Chapter 9: Gases

9.1 Gas Pressure

- Define and calculate pressure (40)
- Understand the units used to measure pressure and convert between them (5)
- Define work and investigate pressure-volume work

9.2 Barometric Pressure

- Calculate barometric pressure (40)
- Understand how pressure is calculated using a manometer (5)

9.3 Gas Laws: Pressure, Temperature, Volume

- Perform calculations using Gay-Lussac's Law (40)
- Perform calculations using Charles's Law (40)
- Perform calculations using Boyle's Law (40)

9.4 Gas Laws: Ideal Gas Laws

- Understand Avogadro's Law
- Understand the Ideal Gas Law (5)
- Understand standard conditions (5)

9.5 Gas Law Calculations

- Apply the ideal gas law to solve problems (40, 5)
- Apply the combined gas law to solve problems

9.6 Gas Stoichiometry

- Determine the density of a gas (40)
- Perform calculations of gases using stoichiometry (5)
- Calculate the molar mass of a gas (40)

9.7 Standard States

- Compare and contrast standard and nonstandard states (5)

9.8 Gas Stoichiometry: Partial Pressure Calculations

- Perform calculations using Dalton's Law (40)
- Calculate and use the molar volume of a gas under standard temperature and pressure conditions (5)
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9.9 Diffusion Of Gases

- Describe diffusion and calculate rate of diffusion

9.10 Effusion of Gases

- Describe effusion and calculate rate of effusion using Graham's law (40)
- Determine molar mass using Graham's law

9.11 The Kinetic Molecular Theory

- Understand the basics of the kinetic molecular theory of gases
 - Understand the kinetic molecular theory and how it connects to the gas laws
-

- Calculate the molecular velocity of a gas at a given temperature

9.12 Non Ideal Gas Behavior

- Describe non-ideal gas behavior and identify the conditions where it occurs
- Describe gas behavior using the van der Waals equation (5)
- Compare and contrast ideal gas behavior and the van der Waals equation (40)

Chapter 10: Liquids and Solids

10.1 Intermolecular and Intramolecular Forces

- Compare and contrast inter- and intra- molecular forces (5)

10.2 Types of Intermolecular Forces

- Define and describe dispersion forces (5)
- Define and describe dipole-dipole attractions between molecules (5)
- Define and describe hydrogen bonding (5)

10.3 Properties of Liquids: Forces of Nature

- Identify examples of cohesive forces and adhesive forces in nature

10.4 Properties of Liquids

- Define and describe viscosity
- Identify examples of surface tension in nature
- Describe capillary action and calculate capillary rise

10.5 Phase Transitions

- Define and describe vaporization and condensation

10.6 Phase Transitions: Vaporization, Sublimation, and Melting

- Define boiling point and describe how it can change at various pressures (5)
- Calculate heat required to vaporize a liquid given the enthalpy of vaporization (40)
- Compare and contrast the properties of melting and freezing (5)
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10.7 Phase Diagrams: Heating and Cooling Curves

- Calculate the heat released or absorbed during phase changes and read heating and cooling curves (40)

10.8 Phase Diagrams: Interpretations

- Read and interpret a phase diagram (5)

10.9 Phase Diagrams; Critical Point, and Supercritical fluids

- Describe supercritical fluids and determine the critical point

10.10 Types and Properties of Solids

- Compare and contrast crystalline and amorphous solids
- Distinguish between ionic solids, metallic solids, covalent network solid, and molecular solids (5)
- Identify properties of solids (5)

10.11 The Structures of Metals

- Identify and describe types of unit cells in crystalline lattices
- Calculate atomic radius and density for metals (40)

10.12 Ionic Crystals

- Describe various structures of ionic crystals
 - Identify and describe types of unit cells in ionic crystals
 - Calculate ionic radii in ionic crystals (40)
-

- Investigate bonding of atoms in solids (5)

10.13 Ionic Crystals: X-ray Crystallography

- Understand the process of x-ray crystallography (40)

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11.1 The Solution Process and General Solubility

- Describe the traits of a solution (5)
- Describe the formation of solutions (5)
- Describe the types of interactions that determine the extent to which a solute dissolves in solution
- Explain solubility and the differences between saturated, unsaturated, and supersaturated (5)

11.2 Electrolytes

- Classify solutes in aqueous solution as strong electrolytes, weak electrolytes, and nonelectrolytes (5)
- Describe the qualities of ionic electrolytes
- Describe the qualities of covalent electrolytes

11.3 Gas Solubility

- Describe the properties of solutions of gases in liquids
- Apply Henry's law to solve problems (40)

11.4 Colligative Properties

- Identify colligative properties (5)

11.5 Colligative Properties: Calculations

- Calculate mole fraction and molality (40)

11.6 Colligative Properties: Vapor Pressure

- Calculate vapor pressure (40)
- Determine the boiling point of a solution

11.7 Colligative Properties: Boiling Point Elevation and Freezing Point Depression

- Determine the freezing point of a solution
- Understand the process of distillation

11.8 Colligative Properties: Osmotic Pressure

- Determine osmotic pressure (40)

11.9 Colloids

- Identify properties of colloids
- Describe the preparation of colloidal systems
- Explain the electrical properties of colloidal particles

11.10 Solids and Liquids in Solution

- Describe the properties of solutions of liquids in liquids
- Describe the properties of solutions of solids in liquids

Chapter 12: Kinetics

12.1 Chemical Reaction Rates

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 - Derive rate expressions for relative reactions (40)
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12.2 Chemical Reaction Rates: Experimental Data

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12.3 Factors Affecting Reaction Rates

- Explain how intensive properties of participating reactants affects the rate of reaction
- Explain how temperature and concentration of reactant affects the rate of reaction (5)

12.4 Rate Laws: Definition

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12.5 Rate Laws: Reaction Order and Initial Rate Reactions

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- Determine rate laws from initial rates (40)

12.6 Integrated Rate Laws: Reaction Orders

- Perform calculations for first order reactions (40)
- Perform calculations for second order reactions (40)
- Perform calculations for zero order reactions (40)
- Use spectroscopic methods to measure reaction rates

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- Perform rate calculations using half life (40)

12.8 Theories of Chemical Kinetics

- Define collision theory and its postulates
- Calculate activation energy and the arrhenius equation (40)

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- Identify the molecularity of elementary reactions
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12.10 Catalysis

- Define catalysts
- Describe homogeneous catalysts (5)
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13.1 Chemical Equilibria

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13.2 Chemical Equilibria: Reaction Quotient Calculations

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13.3 Chemical Equilibria: Homogeneous and Heterogeneous Expressions

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- Understand the effect of change in concentration on equilibrium (3)
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13.5 Le Châtelier's Principle: Temperature and Catalyst Changes

- Understand the effect of change in temperature on equilibrium (5)
 - Understand how catalysts affect equilibrium (5)
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13.6 Equilibrium Calculations: Concentration Changes

- Determine relative changes in concentrations (40)
- Calculate changes in concentration (5)

13.7 Equilibrium Calculations: Equilibrium Constants

- Calculate an equilibrium constant (40)
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14.1 Bronsted Lowry Acids and Bases

- Identify acids, bases, and conjugate acid-base pairs according to the Bronsted-Lowry definition (5)

14.2 Acid-base properties of water

- Read and write equations for acid and base ionization reactions and the self ionization of water (5)
- Describe the acid-base behavior of amphiprotic substances (5)
- Investigate the special properties of water (5)

14.3 pH and pOH

- Calculate hydronium and hydroxide ion concentrations
- Identify hydronium and hydroxide ion concentrations on the pH and pOH scales (5)
- Perform calculations relating pH and pOH (40)

14.4 pH and pOH: Solution Identification

- Classify solution as an acidic, basic, or neutral based on the pH value, concentration of hydronium and hydroxide ions (40, 5)

14.5 pH Calculations

- Calculate the pH of a strong acid (5)
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14.6 Acid and Base Strengths: K_a and K_b

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- Explain the relationship between conjugate bases and acids (5)
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 - Describe how salts form from weak acids and strong bases
 - Describe how salts form from weak acids and weak bases
-

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- Write equations and solubility products (5)

15.2 Solubility Product: K_{sp} and its Calculations

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- Describe and apply the common ion effect (40, 5)

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- Explain what is meant by multiple equilibria
 - Perform calculations using multiple equilibria (40)
 - Explain the effects of dissolution on equilibria
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- Explain how the dispersal of matter and energy affect spontaneity

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- Predict the sign of entropy (5)

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16.4 Free Energy Change

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16.5 Free Energy: Equilibrium Constant and Temperature Effects

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- Explain the basics of electrochemistry

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17.3 Basic Redox Reactions

- Balance basic oxidation-reduction reactions (5)

17.4 Galvanic Cells

- Explain galvanic cells and cell potential (5)
- Interpret cell notation to describe a reaction (5)

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- Define standard reduction potential
- Calculate standard reduction potential (5)

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- Explain the relationship between free energy, equilibrium constant and standard cell potential (5)
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- Calculate cell potential of a concentration cell (40)

17.8 Batteries and Fuel Cells

- Explain how primary batteries work
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- Describe corrosion

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- Describe electrolysis
-

- Describe electrolysis of various solutions
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- Investigate properties of Groups 2, 12, 13, 14, and 15 (5)

18.2 Representative Metals: Structure and Properties

- Investigate the properties of the alkali metals (5)

18.3 Metalloids and Non-Metals: Structures and Properties

- Describe the general preparation, properties, and uses of the metalloids
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- Understand how semiconductors have properties intermediate between metals and nonmetals (5)

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- Describe the properties, preparation, and compounds of representative metal oxides, peroxides, and hydroxides

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- Describe the properties, preparation, and compounds of hydrogen
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- Identify the physical and chemical properties of carbon and the carbon group (5)

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- Describe the preparation, properties, and uses of some representative metal carbonates
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19.1 Transition Metals and Their Compounds

- Outline the general approaches for the isolation of transition and representative metals from natural sources
 - Describe typical physical and chemical properties of the transition metals
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- Understand geometries of coordinate complexes (5)
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- Understand the basic premise of crystal field theory (CFT) and the splitting patterns for octahedral, tetrahedral and square planar complexes
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20.1 Hydrocarbons: Physical and Chemical Properties

- Recognize physical and chemical properties of alkanes (10)

20.2 Hydrocarbons: Alkanes

- Understand how to name and write formulas for alkanes (5)

20.3 Hydrocarbons: Alkenes

- Name and write formulas for alkenes and recognize physical properties of alkenes and their isomers (5)

20.4 Hydrocarbons: Alkynes

- Name and write formulas for alkynes and recognize physical properties of alkynes (5)

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- Name and write formulas for aromatic compounds and recognize physical and chemical properties of aromatic compounds (5)
- Name and write formulas for aromatic hydrocarbons

20.6 Alcohols and Ethers

- Identify the characteristics of alcohols (5)
- Recognize physical and chemical properties of ethers (5)

20.7 Aldehydes, Ketones, Carboxylic Acids, and Esters

- Identify the characteristics of aldehydes and ketones (5)
- Identify the characteristics of carboxylic acids and esters (5)

20.8 Amines and Amides

- Identify the characteristics of amines (5)
- Identify the characteristics of amides (5)

Chapter 21: Nuclear Chemistry

21.1 Nuclear Structure and Stability

- Understand the basics of nuclear chemistry (5)
- Describe and calculate nuclear binding energy (40)
- Explain nuclear stability

21.2 Nuclear Equations

- Compare types of particles in nuclear reactions (5)
- Write and balance equations for alpha, beta, positron, and gamma decay

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- Compare and contrast alpha, beta, positron, and gamma radiation (5)
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21.4 Half-Lives

- Calculate half-lives of radioactive elements (40)
- Understand how radioisotopes are used to determine the age of an object (40)

21.5 Nuclear Energy

- Explain the synthesis of nuclides
- Understand how a nuclear power plant operates

21.6 Nuclear Fission and Nuclear Fusion

- Describe the process of nuclear fission (35)
 - Describe the process of nuclear fusion
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