



# Principles of General Chemistry (Atoms First)

978-1-63545-091-0



To learn more about all our offerings  
Visit [Knewton.com](https://www.knewton.com)



Source	Author(s) (Text or Video)	Title(s)	Link (where applicable)
OpenStax	Senior Contributing Authors: Paul Flowers - University of North Carolina at Pembroke Klaus Theopold - University of Delaware Richard Landley - Stephen F. Austin State University	Chemistry: Atoms First	<a href="#">OpenStax</a>
Professor Dave Explains	Dave Farina	Professor Dave Explains	<a href="#">YouTube Channel</a>

Alta Principles of General Chemistry (Atoms First) was developed to meet the scope and sequence of a typical two-semester introduction to chemistry course. To develop the course, Knewton used three main sources of content: Openstax, videos created by a Chemistry Professor with a graduate degree from Cal State Northridge who has taught in various undergraduate settings but specializes in organic chemistry, and a team of Subject Matter Experts (SMEs). The SMEs come from diverse backgrounds and are all accomplished academics in the field of Chemistry.

Alta Principles of General Chemistry (Atoms First) has at least two instructional sequences for every learning objective, giving students multiple opportunities to learn new concepts. Between our instructional texts, videos, and SMEs, we were able to solicit ideas from chemistry instructors and students. Alta Principles of General Chemistry covers the typical breadth of introductory chemistry topics and also provides the necessary depth to ensure the course is manageable and engaging for instructors and students alike.

---

## Principles of General Chemistry (Atoms First) | Table of Contents

### Chapter 1: Essential Ideas

- 1.1 Chemistry: The Central Science
    - Understand the aim, scope, and importance of chemistry
  - 1.2 The Scientific Method
    - Understand how the scientific method works
    - Understand the domains of chemistry
  - 1.3 Matter, Mass, and Weight
    - Compare and contrast properties of three states of matter
    - Distinguish between mass and weight
    - Understand the law of conservation of matter
  - 1.4 Atoms and Molecules
    - Identify and describe atoms and molecules
  - 1.5 Elements, Compounds, and Mixtures
    - Classify matter as elements and compounds
    - Distinguish between heterogeneous and homogeneous mixtures
  - 1.6 Physical and Chemical Properties
    - Understand physical properties and changes
    - Understand chemical properties and changes
    - Predict physical and chemical changes
  - 1.7 Extensive and Intensive Properties
    - Understand extensive and intensive properties of matter
  - 1.8 Measurements
    - Understand how to use metric and SI system of units names and abbreviations
    - Identify and use the SI units for length, volume, and mass
  - 1.9 Calculations using Measurements
    - Perform density and specific gravity calculations
    - Survey quantities and units, understand measurements, and learn how to solve problems
    - Identify and use the SI units for temperature and time
  - 1.10 Measurement Uncertainty
    - Distinguish between accurate measurements and precise measurements
    - Use precision and trueness in calculations of relative error values and calculations of sample and relative standard deviation
  - 1.11 Significant Figures
    - Determine the number of significant figures in a measured number
    - Use significant figures in calculations
  - 1.12 Dimensional Analysis
    - Solve single-step unit conversion problems using dimensional analysis
    - Solve multi-step unit conversion problems using dimensional analysis
    - Use Fahrenheit, Celsius, and Kelvin temperature scales and convert between them
-

## 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
- 2.3 Atomic Structure
  - Determine the number of protons, electrons, and neutrons in the atom from the atomic and mass numbers
  - Calculate the average atomic mass of an element given isotopic mass and fractional abundance of each isotope
- 2.4 Isotopes
  - Identify isotopes
  - Understand the natural abundances and distributions of the elements
- 2.5 Chemical Symbols
  - Read and interpret chemical symbols
- 2.6 Chemical Formulas
  - Read and write molecular formulas given atomic composition
  - Identify and interpret structural formulas

## Chapter 3: Electron Configuration and Properties of Elements

- 3.1 Classic Electromagnetic Theory and Waves
    - Understand electromagnetic radiation and waves
    - Determine the wavelength and frequency of radiation and identify its place in the electromagnetic spectrum
    - Understand standing waves
  - 3.2 Bohr's Atomic theory
    - Understand Bohr's atomic model
  - 3.3 Bohr's Model: Energy Calculations of an Electron
    - Calculate the energy of an electron in a Bohr orbit
    - Calculate the energy of electron transitions in a one-electron (bohr) system
  - 3.4 Quantum Theory: Introduction
    - Calculate the wavelength of a particle
    - Understand the Heisenberg Uncertainty Principle
    - Understand the quantum-mechanical model of an atom
  - 3.5 Quantum Numbers
    - Define and describe the quantum numbers
    - Understand the Pauli Exclusion Principle
  - 3.6 Electron Configurations
    - Describe the electron configuration of an atom
    - Understand the Aufbau Principle
    - Understand magnetism and explore magnetic materials
-

- 3.7 Orbital Diagrams
  - Read and interpret orbital diagrams
  - Distinguish between core and valence electrons
- 3.8 Extensions of Electron Configurations
  - Determine the electron configuration of an element using the periodic table
  - Identify and write the electron configuration of an ion
  - Predict electron configurations of split d orbitals for selected transition metal atoms or ions
- 3.9 Variations in Element Properties: Covalent and Ionic Radii
  - Recognize variations in covalent radius using periodic trends
  - Recognize variations in ionic radii using periodic trends
- 3.10 Variations in Elemental Properties: Ionization Energies and Electron Affinities
  - Recognize variations in ionization energies using periodic trends
  - Recognize variations in electron affinities using periodic trends
- 3.11 Paradoxes within the Classic Electromagnetic Theory
  - Understand blackbody radiation
  - Understand the photoelectric effect
  - Understand how elements emit line spectra
- 3.12 The Periodic Table
  - Understand the history of the periodic table
  - Understand the organization of the periodic table
- 3.13 The Periodic Table: Interpretation and Identification
  - Read and interpret an element block on the periodic table
  - Identify which group on the periodic table an element belongs to
- 3.14 Ionic Compounds
  - Define ions and distinguish between monatomic ions and polyatomic ions
  - Describe properties of ionic compounds
- 3.15 Molecular Compounds
  - Understand the type of bonding that connects atoms in a molecular compound
  - Predict the type of bonding in a compound

#### **Chapter 4: Chemical Bonding and Molecular Geometry**

- 4.1 Ionic Bonding: Cations and Anions
    - Understand the formation of ionic compounds
    - Determine the electronic structures of cations
    - Determine the electronic structure of anions
    - Define the meaning and primary basis of qualitative analysis
  - 4.2 Lattice Energy Calculations
    - Understand ionic bond strength and lattice energy
    - Calculate lattice energy using the Born-Haber cycle
  - 4.3 Covalent Bonding: Understand the formation of covalent bonds
    - Understand the formation of covalent bonds
    - Compare and contrast pure and polar covalent bonds
-

- 4.4 Covalent Bonding: Electronegativity and Bond Strength
  - Determine the type of bond from the electronegativity of two atoms
  - Determine covalent bond strength
- 4.5 Chemical Nomenclature: Ionic Compounds and Ions
  - Write the formula of and name an ionic compound with a simple ion
  - Write the formula of and name a polyatomic ion or compound containing it
  - Write the formula of and name a metal ion with a variable charge
- 4.6 Chemical Nomenclature: Molecular Compounds
  - Write the formula of and name a molecular compound
- 4.7 Chemical Nomenclature: Acids
  - Write the formula of and name a binary acid
  - Write the formula of and name an oxyacid
- 4.8 Lewis Structures
  - Read lewis structures and draw a lewis structure for an atom
  - Understand how to draw lewis structures for covalent compounds using the octet rule
- 4.9 Lewis Structures: Octet Rules
  - Understand the octet rule and how to represent triple and double bonds when drawing lewis structures
  - Identify exceptions to the octet rule
  - Write Lewis diagrams with octet rule exceptions
- 4.10 Formal Charges and Resonance
  - Calculate formal charge
  - Use formal charge to predict molecular structure
  - Recognize resonance forms
- 4.11 VSEPR Theory
  - Understand how to determine molecular shape using the VSEPR theory
  - Compare and contrast electron-pair geometry and molecular structure
  - Predict electron-pair geometry and molecular structure using VSEPR theory
- 4.12 Molecular Geometry and Polarity
  - Understand the role that molecular geometry plays in determining polarity of a compound
  - Determine the structure of multi-center molecules

## **Chapter 5: Advanced Theories of Covalent Bonding**

- 5.1 Valence Bond Theory
    - Understand atomic orbital overlap
    - Identify sigma and pi bonds
  - 5.2 Hybridization
    - Understand hybridization
    - Understand sp (1, 2, and 3) hybrid orbitals
    - Understand sp (1, 2, and 3) hybridization
  - 5.3 Hybrid Atomic Orbitals
    - Understand sp<sup>3</sup>d and sp<sup>3</sup>d<sup>2</sup> hybridization
-

- 5.4 Hybrid Atomic Orbitals: Assignments
  - Understand the assignment of hybrid orbitals to central atoms
  - Understand orbital overlap in multiple bonds
- 5.5 Molecular Orbital Theory: Energy Diagrams
  - Understand the molecular orbital theory
  - Understand molecular orbital energy diagrams
- 5.6 Molecular Orbital Theory: Bond Order
  - Calculate bond order
  - Understand bonding in diatomic molecules

## **Chapter 6: Substances and Solutions**

- 6.1 Formula Mass
    - Determine formula mass for covalent substances
    - Determine formula mass for ionic compounds
  - 6.2 The Mole: Definition and Use
    - Understand the mole as a unit of measurement
  - 6.3 The Mole: Conversions to Grams
    - Convert moles to grams and grams to moles for an element or a compound
  - 6.4 The Mole: Conversions to Atoms and Molecules
    - Derive the number of atoms from mass for an element
    - Derive the number of atoms and molecules from the mass of a compound
  - 6.5 Empirical Formula
    - Calculate percent composition of a compound given mass of components
    - Determine a compound's empirical formula from the masses of its elements
    - Determine a compound's empirical formula from percent composition
  - 6.6 Molecular Formula
    - Calculate percent composition given molecular formula
    - Derive a molecular formula for a compound given percent composition and molecular mass
  - 6.7 Molarity: Definition and Calculations
    - Recognize solutions as mixtures and distinguish between solute and solvent
    - Derive moles and volumes from molar concentrations
  - 6.8 Molarity and Molar Concentrations
    - Calculate molar concentrations from mass of a solute
    - Determine mass of a solute given volume of a solution
    - Determine volume of a solution given mass of a solute
  - 6.9 Dilutions: Determining Concentration
    - Understand how to calculate concentrations for diluted solutions
    - Determine the concentration of diluted solution
  - 6.10 Dilutions: Determining volume
    - Determine the volume of a diluted solution
    - Determine the volume of a concentrated solution needed for dilution
-

- 6.11 Concentrations of Solutions: Mass and Volume Percentages
  - Calculate the mass percentage of a component in a solution
  - Calculate volume percentage
  - Calculate mass-volume percentage
- 6.12 Concentrations of Solutions: Part per Million and Parts per Billion
  - Calculate parts per million (ppm) and parts per billion (ppb) concentrations

## 7.1 - Chapter 7: Stoichiometry of Chemical Reactions

- 7.1 Writing and Balancing Chemical Equations
  - Understand how to represent a chemical reaction using an equation
  - Write and balance chemical equations
- 7.2 Writing and Balancing Ionic Equations
  - Write and balance chemical equations for ionic reactions
- 7.3 Classifying Chemical Reactions: Precipitation
  - Understand precipitation reactions and solubility rules
  - Apply solubility rules
- 7.4 Classifying Chemical Reactions: Acid-Base
  - Write and balance chemical equations for acid-base reactions
- 7.5 Classifying Chemical Reactions: Redox Reactions and Oxidation States
  - Understand oxidation-reduction reactions
  - Predict oxidation numbers
- 7.6 Classifying Chemical Reactions: Balancing Redox Reactions
  - Balance redox reactions
  - Write half reactions
- 7.7 Reaction Stoichiometry
  - Calculate the molar ratio between two substances given the balanced equation
  - Calculate the amount of moles of a reactant required given moles of the other reactant(s) and a balanced equation
  - Calculate the amount of product moles generated by a reaction
  - Calculate the mass of a product/reactant given a balanced chemical equation
- 7.8 Reaction Yields
  - Identify the limiting reactant
  - Calculate theoretical yield and percent yield of a reaction given masses of reactants and products
- 7.9 Quantitative Analysis
  - Understand how to complete titration calculations
  - Understand how to complete gravimetric analysis calculations
  - Understand how to complete combustion analysis calculations

## Chapter 8: Gases

- 8.1 Gas Pressure
    - Define and calculate pressure
    - Understand the units used to measure pressure and convert between them
    - Define work and investigate pressure-volume work
-



- 8.2 Barometric Pressure
  - Calculate barometric pressure
  - Understand how pressure is calculated using a manometer
- 8.3 Gas Laws: Pressure, Temperature, Volume
  - Perform calculations using Gay-Lussac's Law
  - Perform calculations using Charles's Law
  - Perform calculations using Boyle's Law
- 8.4 Gas Laws: Ideal Gas Laws
  - Understand Avogadro's Law
  - Understand the Ideal Gas Law
  - Understand standard conditions
- 8.5 Gas Law Calculations
  - Apply the ideal gas law to solve problems
  - Apply the combined gas law to solve problems
- 8.6 Gas Stoichiometry
  - Determine the density of a gas
  - Perform calculations of gases using stoichiometry
  - Calculate the molar mass of a gas
- 8.7 Standard States
  - Compare and contrast standard and nonstandard states
- 8.8 Gas Stoichiometry: Partial Pressure Calculations
  - Perform calculations using Dalton's Law
  - Calculate and use the molar volume of a gas under standard temperature and pressure conditions
  - Calculate the pressure of a gas collected over water
- 8.9 Diffusion Of Gases
  - Describe diffusion and calculate rate of diffusion
- 8.10 Effusion of Gases
  - Describe effusion and calculate rate of effusion using Graham's law
  - Determine molar mass using Graham's law
- 8.11 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
- 8.12 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
  - Compare and contrast ideal gas behavior and the van der Waals equation

## **Chapter 9: Thermochemistry**

- 9.1 Energy Basics
    - Define energy
    - Define and describe thermal energy, temperature, and heat
-

- 9.2 Heat and Heat Capacity
  - Define heat capacity and specific heat
  - Solve heat capacity problems
  - Understand how to use specific heat in heat loss / gain calculations
- 9.3 Calorimetry
  - Understand calorimetry techniques
  - Calculate heat and related properties using bomb calorimetry
- 9.4 Heat transfer and Calorimetry
  - Understand heat transfer between substances
- 9.5 Enthalpy
  - Understand the first law of thermodynamics
  - Calculate heat production using enthalpy of combustion
  - Solve enthalpy problems
- 9.6 Standard Enthalpies of Formation
  - Determine the standard enthalpy of formation
  - Determine the amount of heat involved in a chemical change using Hess's Law

## **Chapter 10: Liquids and Solids**

- 10.1 Intermolecular and Intramolecular Forces
    - Compare and contrast inter- and intra- molecular forces
  - 10.2 Types of Intermolecular Forces
    - Define and describe dispersion forces
    - Define and describe dipole-dipole attractions between molecules
    - Define and describe hydrogen bonding
  - 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
    - Calculate heat required to vaporize a liquid given the enthalpy of vaporization
    - Compare and contrast the properties of melting and freezing
    - Compare and contrast the properties of sublimation and deposition
  - 10.7 Phase Diagrams: Heating and Cooling Curves
    - Calculate the heat released or absorbed during phase changes and read heating and cooling curves
  - 10.8 Phase Diagrams: Interpretations
    - Read and interpret a phase diagram
  - 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
  - Identify properties of solids
- 10.11 The Structures of Metals
  - Identify and describe types of unit cells in crystalline lattices
  - Calculate atomic radius and density for metals
- 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
  - Investigate bonding of atoms in solids
- 10.13 Ionic Crystals: X-ray Crystallography
  - Understand the process of x-ray crystallography

## **Chapter 11: Solutions and Colloids**

- 11.1 The Solution Process
    - Describe the traits of a solution
    - Describe the formation of solutions
  - 11.2 General Solubility
    - 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
  - 11.3 Electrolytes
    - Classify solutes in aqueous solution as strong electrolytes, weak electrolytes, and nonelectrolytes
    - Describe the qualities of ionic electrolytes
    - Describe the qualities of covalent electrolytes
  - 11.4 Gas Solubility
    - Describe the properties of solutions of gases in liquids
    - Apply Henry's law to solve problems
  - 11.5 Colligative Properties
    - Identify colligative properties
  - 11.6 Colligative Properties: Calculations
    - Calculate mole fraction and molality
  - 11.7 Colligative Properties: Vapor Pressure
    - Calculate vapor pressure
    - Determine the boiling point of a solution
  - 11.8 Colligative Properties: Boiling Point Elevation and Freezing Point Depression
    - Determine the freezing point of a solution
    - Understand the process of distillation
  - 11.9 Colligative Properties: Osmotic Pressure
    - Determine osmotic pressure
-

- 11.10 Colloids
  - Identify properties of colloids
  - Describe the preparation of colloidal systems
  - Explain the electrical properties of colloidal particles
- 11.11 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: Thermodynamics**

- 12.1 Spontaneity
  - Describe spontaneous and nonspontaneous processes
  - Explain how the dispersal of matter and energy affect spontaneity
- 12.2 Entropy
  - Explain and calculate entropy
  - Define microstate and its relationship to entropy
  - Predict the sign of entropy
- 12.3 The Second and Third Laws of Thermodynamics
  - Explain the second law of thermodynamics
  - Explain the third law of thermodynamics
- 12.4 Free Energy Change
  - Define standard free energy change
  - Calculate free energy change
- 12.5 Free Energy: Equilibrium Constant and Temperature Effects
  - Explain how spontaneity is affected by temperature
  - Describe the relationship between free energy changes and equilibrium constants

## **Chapter 13: Equilibrium Concepts**

- 13.1 Chemical Equilibria
    - Describe the nature of chemical equilibria
    - Derive equilibrium constants
  - 13.2 Chemical Equilibria: Reaction Quotient Calculations
    - Write and interpret reaction quotient expressions
  - 13.3 Chemical Equilibria: Homogeneous and Heterogeneous Expressions
    - Compare homogeneous and heterogeneous equilibria
  - 13.4 Le Châtelier's Principle: Concentration and Pressure Changes
    - Understand the effect of change in concentration on equilibrium
    - Understand the effect of change in pressure on equilibrium
  - 13.5 Le Châtelier's Principle: Temperature and Catalyst Changes
    - Understand the effect of change in temperature on equilibrium
    - Understand how catalysts affect equilibrium
  - 13.6 Equilibrium Calculations: Concentration Changes
    - Determine relative changes in concentrations
    - Calculate changes in concentration
-

- 13.7 Equilibrium Calculations: Equilibrium Constants
  - Calculate an equilibrium constant
  - Calculate a missing equilibrium concentration

## Chapter 14: Acid Base Equilibria

- 14.1 Bronsted Lowry Acids and Bases
    - Identify acids, bases, and conjugate acid-base pairs according to the Bronsted-Lowry definition
  - 14.2 Acid-base properties of water
    - Read and write equations for acid and base ionization reactions and the self ionization of water
    - Describe the acid-base behavior of amphiprotic substances
    - Investigate the special properties of water
  - 14.3 pH and pOH
    - Calculate hydronium and hydroxide ion concentrations
    - Identify hydronium and hydroxide ion concentrations on the pH and pOH scales
    - Perform calculations relating pH and pOH
  - 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
  - 14.5 pH Calculations
    - Calculate the pH of a strong acid
    - calculate the pH of a strong base
    - Calculate the pH of a weak base
  - 14.6 Acid and Base Strengths:  $K_a$  and  $K_b$ 
    - Explain acid strength and  $K_a$
    - Explain base strength and  $K_b$
  - 14.7 Acids and Bases: Ionization and Conjugate Acids and Bases
    - Explain the relationship between conjugate acids and bases
    - Explain the relationship between conjugate bases and acids
    - Explain the ionization of weak acids and bases
  - 14.8 Calculations of Acids and Bases
    - Determine  $K_a$  and  $K_b$  from equilibrium concentrations
    - Determine  $K_a$  and  $K_b$  from pH
    - Calculate the pH of a weak acid
  - 14.9 Neutralization Reactions
    - Identify acid base neutralization reactions
  - 14.10 Hydrolysis of Salt Solutions
    - Describe how salts form from weak bases and strong acids
    - Describe how salts form from weak acids and strong bases
    - Describe how salts form from weak acids and weak bases
  - 14.11 pH of a Hydrated Metal Ion
    - Calculate pH of a hydrated metal ion
-

- 14.12 Polyprotic Acids; Descriptions and Calculations
  - Describe monoprotic and diprotic acids
  - Describe triprotic and polyprotic acids
  - Perform calculations for polyprotic acids
- 14.13 Buffers and Buffer Capacity
  - Explain how buffers work
  - Describe buffer capacity
- 14.14 Buffer Mixtures and Calculations
  - Explain how to select a suitable buffer mixture
  - Calculate the pH of a buffer solution using the Henderson Hasselbalch equation
- 14.15 Acid Base Titrations
  - Interpret titration curves
  - Calculate pH during acid base titration
- 14.16 Indicators
  - Understand and interpret acid base indicator data

### **Chapter 15: Equilibria of Other Reaction Classes**

- 15.1 Dissolution
    - Write equations and solubility products
  - 15.2 Solubility Product:  $K_{sp}$  and its Calculations
    - Calculate  $K_{sp}$
    - Perform calculations using  $K_{sp}$
    - Calculate the solubility of a molecule using  $K_{sp}$
  - 15.3 Precipitation
    - Predict precipitation
    - Calculate concentration needed for precipitation
  - 15.4 Selective Precipitation
    - Describe and predict selective precipitation
  - 15.5 Common Ion Effect
    - Describe and apply the common ion effect
  - 15.6 Lewis Acids and Bases
    - Explain Lewis acids, Lewis bases and their reactions
  - 15.7 Complex Ion Formations
    - Explain complex ions
    - Explain formation constants
  - 15.8 Molecular Structure and Acid-Base Strength
    - Describe the relationship between molecular structure and acid-base strength
  - 15.9 Multiple Equilibria
    - Explain what is meant by multiple equilibria
    - Perform calculations using multiple equilibria
    - Explain the effects of dissolution on equilibria
-

## 16.1 - Chapter 16: Electrochemistry

- 16.1 Redox Reactions
  - Explain the basics of electrochemistry
- 16.2 Acidic Redox Reactions
  - Balance acidic oxidation-reduction reactions
- 16.3 Basic Redox Reactions
  - Balance basic oxidation-reduction reactions
- 16.4 Galvanic Cells
  - Explain galvanic cells and cell potential
  - Interpret cell notation to describe a reaction
- 16.5 Standard Reduction Potentials
  - Define standard reduction potential
  - Calculate standard reduction potential
- 16.6 The Nernst Equation
  - Explain the relationship between free energy, equilibrium constant and standard cell potential
  - Calculate free energy and equilibrium constant using standard cell potential
- 16.7 Free Energy and Concentration Cells
  - Calculate cell potential of a concentration cell
- 16.8 Batteries and Fuel Cells
  - Explain how primary batteries work
  - Explain how secondary batteries work
  - Explain how fuel cells work
- 16.9 Corrosion
  - Describe corrosion
- 16.10 Electrolysis
  - Describe electrolysis
  - Describe electrolysis of various solutions
  - Perform various calculations related to electrolysis

## Chapter 17: Kinetics

- 17.1 Chemical Reaction Rates
    - Define rate of reaction
    - Derive rate expressions for relative reactions
  - 17.2 Chemical Reaction Rates: Experimental Data
    - Calculate reaction rates from experimental data
  - 17.3 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
  - 17.4 Rate Laws: Definition
    - Explain rate laws
  - 17.5 Rate Laws: Reaction Order and Initial Rate Reactions
    - Identify reaction order and rate constant units
    - Determine rate laws from initial rates
-

- 17.6 Integrated Rate Laws: Reaction Orders
  - Perform calculations for first order reactions
  - Perform calculations for second order reactions
  - Perform calculations for zero order reactions
- 17.7 Measuring Reaction Rates
  - Use spectroscopic methods to measure reaction rates
- 17.8 Rate Laws: Half Life Reactions
  - Perform rate calculations using half life
- 17.9 Theories of Chemical Kinetics
  - Define collision theory and its postulates
  - Calculate activation energy and the arrhenius equation
- 17.10 Reaction Mechanisms
  - Explain the reaction mechanism process
  - Identify the molecularity of elementary reactions
  - Relate reaction mechanisms to rate laws
- 17.11 Catalysis
  - Define catalysts
  - Describe homogeneous catalysts
  - Describe heterogeneous catalysts

## **Chapter 18: Representative Metals, Metalloids, and Nonmetals**

- 18.1 Periodicity
    - Investigate properties of Groups 2, 12, 13, 14, and 15
  - 18.2 Representative Metals: Structure and Properties
    - Investigate the properties of the alkali metals
  - 18.3 Metalloids and Non-Metals: Structures and Properties
    - Describe the general preparation, properties, and uses of the metalloids
    - Describe the structure and properties of nonmetals
  - 18.4 Semiconductors
    - Understand how semiconductors have properties intermediate between metals and nonmetals
  - 18.5 Boron and Silicon: Structures and Properties
    - Describe the preparation, properties, and compounds of boron and silicon
  - 18.6 Oxygen-Containing Compounds: Structure and Properties
    - Describe the properties, preparation, and compounds of representative metal oxides, peroxides, and hydroxides
  - 18.7 Hydrogen and Carbon: Structure and Properties
    - Describe the properties, preparation, and compounds of hydrogen
    - Understand the carbon cycle
    - Identify the physical and chemical properties of carbon and the carbon group
  - 18.8 Carbonates and Phosphorous: Structure and Properties
    - Describe the preparation, properties, and uses of some representative metal carbonates
    - Describe the properties, preparation, and uses of phosphorus
-



- 18.9 Nitrogen: Structure and Properties
  - Describe the properties, preparation, and uses of nitrogen
  - Understand the nitrogen cycle
  - Understand the phosphorus cycle
- 18.10 Oxygen and Sulfur: Structures and Properties
  - Describe the properties, preparation, and uses of sulfur
  - Describe the properties, preparation, and compounds of oxygen
- 18.11 Halogens: Structure and Properties
  - Describe the preparation, properties, and uses of halogens and halogen compounds
- 18.12 Noble Gases: Structure and Properties
  - Describe the properties, preparation, and uses of the noble gases

### **Chapter 19: Transition Metals and Coordination Chemistry**

- 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
- 19.2 Coordination Chemistry of Transition Metals
  - Understand basic concepts and examples of coordination compounds
  - Understand geometries of coordinate complexes
  - Use standard nomenclature rules for coordination compounds
  - Explain and provide examples of geometric and optical isomerism
- 19.3 Coordination Compounds: Properties and Structures Using Spectroscopy
  - Understand the basic premise of crystal field theory (CFT) and the splitting patterns for octahedral, tetrahedral and square planar complexes
  - Explain spectral and magnetic properties in terms of CFT concepts

### **Chapter 20: Nuclear Chemistry**

- 20.1 Nuclear Structure and Stability
    - Understand the basics of nuclear chemistry
    - Describe and calculate nuclear binding energy
    - Explain nuclear stability
  - 20.2 Nuclear Equations
    - Compare types of particles in nuclear reactions
    - Write and balance equations for alpha, beta, positron, and gamma decay
  - 20.3 Radioactive Decay
    - Compare and contrast alpha, beta, positron, and gamma radiation
  - 20.4 Half-Lives
    - Calculate half-lives of radioactive elements
    - Understand how radioisotopes are used to determine the age of an object
  - 20.5 Nuclear Energy
    - Explain the synthesis of nuclides
    - Understand how a nuclear power plant operates
-

- 20.6 Nuclear Fission and Nuclear Fusion
  - Describe the process of nuclear fission
  - Describe the process of nuclear fusion

### **Chapter 21: Organic Chemistry**

- 21.1 Hydrocarbons: Physical and Chemical Properties
    - Recognize physical and chemical properties of alkanes
  - 21.2 Hydrocarbons: Alkanes
    - Understand how to name and write formulas for alkanes
  - 21.3 Hydrocarbons: Alkenes
    - Name and write formulas for alkenes and recognize physical properties of alkenes and their isomers
  - 21.4 Hydrocarbons: Alkynes
    - Name and write formulas for alkynes and recognize physical properties of alkynes
  - 21.5 Aromatics
    - Name and write formulas for aromatic compounds and recognize physical and chemical properties of aromatic compounds
    - Name and write formulas for aromatic hydrocarbons
  - 21.6 Alcohols and Ethers
    - Identify the characteristics of alcohols
    - Recognize physical and chemical properties of ethers
  - 21.7 Aldehydes, Ketones, Carboxylic Acids, and Esters
    - Identify the characteristics of aldehydes and ketones
    - Identify the characteristics of carboxylic acids and esters
  - 21.8 Amines and Amides
    - Identify the characteristics of amines
    - Identify the characteristics of amides
-