

# Principles of General Chemistry



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Alta Principles of General Chemistry 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 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.

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## 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

#### 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
- Understand extensive and intensive properties of matter
- Predict physical and chemical changes

#### 1.7 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

#### 1.8 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

#### 1.9 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

#### 1.10 Significant Figures

- Determine the number of significant figures in a measured number
- Use significant figures in calculations

#### 1.11 Dimensional Analysis

- Solve single-step unit conversion problems using dimensional analysis
- Solve multi-step unit conversion problems using dimensional analysis

#### 1.12 Temperature Conversions

- 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

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- Identify and interpret structural formulas

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- Understand the history of the periodic table
- Understand the organization of the periodic table

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- Read and interpret an element block on the periodic table
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- Define ions and distinguish between monatomic ions and polyatomic ions
- Describe properties of ionic compounds

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- Predict the type of bonding in a compound

### 2.11 Chemical Nomenclature: Ionic Compounds & Ions

- Write the formula of and name an ionic compound with a simple ion
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- Write the formula of and name a molecular compound

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### **Chapter 3: Substances and Solutions**

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- Determine formula mass for ionic compounds

#### 3.2 The Mole: Definition and Use

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#### 3.3 The Mole: Conversions to Grams

- Convert moles to grams and grams to moles for an element or a compound

#### 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

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- 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

#### 3.6 Molecular Formula

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- Derive a molecular formula for a compound given percent composition and molecular mass

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#### 4.1 Writing and Balancing Chemical Equations

- Understand how to represent a chemical reaction using an equation
- Write and balance chemical equations

#### 4.2 Writing and Balancing Ionic Equations

- Write and balance chemical equations for ionic reactions
-

#### 4.3 Classifying Chemical Reactions: Precipitation

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- Apply solubility rules

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- Write and balance chemical equations for acid-base reactions

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- Calculate the mass of a product/reactant given a balanced chemical equation

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- Understand Bohr's atomic model

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- Understand the Pauli Exclusion Principle

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- Describe the electron configuration of an atom
- Understand the Aufbau Principle
- Understand magnetism and explore magnetic materials

### 6.7 Orbital Diagrams

- Read and interpret orbital diagrams
- Distinguish between core and valence electrons

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- Determine the electron configuration of an element using the periodic table
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- Predict electron configurations of split d orbitals for selected transition metal atoms or ions

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  - Determine the electronic structures of cations
-

- Determine the electronic structure of anions
- Define the meaning and primary basis of qualitative analysis

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- Determine covalent bond strength

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#### 7.6 Lewis Structures: Octet Rules

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- Write Lewis diagrams with octet rule exceptions

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

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- Predict electron-pair geometry and molecular structure using VSEPR theory

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- Determine the structure of multi-center molecules

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

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- Understand sp<sup>3</sup>d and sp<sup>3</sup>d<sup>2</sup> hybridization

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-



### 8.5 Molecular Orbital Theory: Energy Diagrams

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## Chapter 9: Gases

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

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- Calculate barometric pressure
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- Understand the Ideal Gas Law
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- Apply the ideal gas law to solve problems
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- Determine the density of a gas
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- Compare and contrast standard and nonstandard states

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- Describe diffusion and calculate rate of diffusion

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

### 9.11 The Kinetic Molecular Theory

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- Understand the kinetic molecular theory and how it connects to the gas laws
- Calculate the molecular velocity of a gas at a given temperature

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- Describe non-ideal gas behavior and identify the conditions where it occurs
- Describe gas behavior using the van der Waals equation
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## 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

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### 10.3 Properties of Liquids: Forces of Nature

- Identify examples of cohesive forces and adhesive forces in nature

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- Define and describe viscosity
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- Describe capillary action and calculate capillary rise

### 10.5 Phase Transitions

- Define and describe vaporization and condensation

### 10.6 Phase Transitions: Vaporization, Sublimation & 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
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### 10.8 Phase Diagrams: Interpretations

- Read and interpret a phase diagram

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- Describe supercritical fluids and determine the critical point

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

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

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- 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

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- Understand the process of x-ray crystallography

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- Describe the traits of a solution
- Describe the formation of solutions
- 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

#### 11.2 Electrolytes

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- Describe the qualities of ionic electrolytes
- Describe the qualities of covalent electrolytes

#### 11.3 Gas Solubility

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#### 11.4 Colligative Properties

- Identify colligative properties

#### 11.5 Colligative Properties: Calculations

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#### 11.6 Colligative Properties: Vapor Pressure

- Calculate vapor pressure
- Determine the boiling point of a solution

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

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- Determine osmotic pressure

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- 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

- Define rate of reaction
- Derive rate expressions for relative reactions

### 12.2 Chemical Reaction Rates: Experimental Data

- Calculate reaction rates from experimental data

### 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

### 12.4 Rate Laws: Definition

- Explain rate laws

### 12.5 Rate Laws: Reaction Order & Initial Rate Reactions

- Identify reaction order and rate constant units
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### 12.6 Integrated Rate Laws: Reaction Orders

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- Use spectroscopic methods to measure reaction rates

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### 12.8 Theories of Chemical Kinetics

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- Calculate activation energy and the arrhenius equation

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- Derive equilibrium constants

### 13.2 Chemical Equilibria: Reaction Quotient Calculations

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  - Understand the effect of change in pressure on equilibrium
-

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- Understand how catalysts affect equilibrium

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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

### 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 & pOH

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- Identify hydronium and hydroxide ion concentrations on the pH and pOH scales
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- Explain the relationship between conjugate bases and acids
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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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- Explain how buffers work
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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

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- Describe the properties, preparation, and uses of the noble gases
-



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- 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 basic concepts and examples of coordination compounds
- Understand geometries of coordinate complexes
- Use standard nomenclature rules for coordination compounds
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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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- Recognize physical and chemical properties of alkanes

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

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- Name and write formulas for alkynes and recognize physical properties of alkynes

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- Name and write formulas for aromatic compounds and recognize physical and chemical properties of aromatic compounds

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- Identify the characteristics of alcohols
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  - Explain nuclear stability
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- Compare and contrast alpha, beta, positron, and gamma radiation

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- Describe the process of nuclear fission
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