



# Introduction to Chemistry

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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	<a href="#">OpenStax</a>
Professor Dave Explains	Dave Farina	Professor Dave Explains	<a href="#">YouTube Channel</a>

Alta Introduction to Chemistry aims to develop the basic chemical principles, such as atomic structure, chemical classifications, bonding, chemical reactions, gas laws, and thermodynamics. The course was developed to meet the scope and sequence of a typical one semester introductory chemistry course. To develop the course, Knewton used three main sources of content: Openstax Chemistry, 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 Chemistry field.

Alta Introduction to 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 Introduction to Chemistry covers the typical breadth of 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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## Introduction to Chemistry

### Chapter 1. An Introduction to Chemistry

- Chemistry in the World
  - Understand the scope, importance, and aim of chemistry
  - Identify examples of chemistry encountered in daily life
- The Scientific Method
  - Understand the scientific method

### Chapter 2. Measurement and Problem Solving

- Scientific Notation
  - Express numbers in standard notation using prefixes and in scientific notation
- Accuracy, Precision, and Significant Figures
  - Distinguish between accuracy and precision in measurements
  - Determine the number of significant figures in measurements
  - Use significant figures when performing calculations
- The Basic Units of Measurement
  - Understand how to use the SI system for units names and abbreviations
  - Identify and use SI units for length, volume, and mass
  - Identify and use the SI units for time and temperature
- Problem Solving, Unit Conversion, and Dimensional Analysis
  - Solve unit conversion problems using dimensional analysis: single step
  - Solve unit conversion problems using dimensional analysis: multiple steps
  - Use Celsius, Fahrenheit, and Kelvin temperature scales and convert between them
- Converting Units Raised to a Power
  - Solve conversion problems involving units raised to a power
- Density
  - Perform specific gravity and density calculations

### Chapter 3. Matter and Energy

- Matter, Mass, and Weight
    - Compare and contrast the three states of matter
    - Distinguish between weight and mass
  - Atoms, Molecules, Compounds, Mixtures
    - Identify and describe molecules and atoms
    - Classify matter as elements or compounds
    - Distinguish between homogeneous and heterogeneous mixtures
  - Physical and Chemical Properties and Changes
    - Understand physical properties and physical changes
    - Understand chemical properties and chemical changes
  - Conservation of Mass
    - Understand and demonstrate the law of conservation of matter
  - Energy
    - Define the types of energy
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- Define thermal energy and heat and distinguish between exothermic and endothermic processes
- Calculate heat capacity given heat and temperature change

#### Chapter 4. Atoms and Elements

- The Evolution of the Atomic Theory
  - Understand Dalton's Atomic Theory
  - Describe modern atomic theory and recognize the scientists involved
- Atomic Structure
  - Identify and describe the subatomic particles that make up an atom
- Identifying Elements
  - Determine the number of protons, electrons, and neutrons in the atom by using the atomic and mass numbers
  - Read and identify chemical symbols
- The Periodic Table
  - Read and interpret element blocks on the periodic table
  - Identify the group on the periodic table an element belongs to
  - Understand how elements are arranged in the periodic table
- Identifying Ions and Isotopes
  - Define ions and distinguish between monatomic and polyatomic ions
  - Determine the number of protons, electrons, and neutrons in the isotope from the atomic symbol and write the atomic symbol for the specific isotope
- Calculating Atomic Mass
  - Calculate the average atomic mass of an element given isotopic mass and fractional abundance isotopes

#### Chapter 5. Molecules and Compounds

- An Introduction to Molecules: Constant Composition
  - Understand the law of definite and the law of multiple proportions
- Molecular and Structural Formulas
  - Read and write molecular formulas for given atomic composition
  - Read and interpret structural formulas
- Ionic and Molecular Compounds
  - Describe the properties of ionic compounds
  - Understand the type of bonding between atoms in a molecular compound
- Naming Ionic Compounds
  - Write the name and formula of an ionic compound with a simple ion
  - Write the name and formula of a polyatomic ion or compound containing it
  - Write the name and formula of a metal ion with a variable charge
- Naming Molecular Compounds and Acids
  - Write the name and formula of a molecular compound
  - Write the name and formula of a binary acid
  - Write the name and formula of an oxyacid
- Calculating Formula Mass
  - Determine the formula mass for covalent substances
  - Determine the formula mass for ionic compounds

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#### Chapter 6. Chemical Composition

- The Mole
  - Understand the mole as a unit in measurements
  - Convert moles to grams and grams to moles for elements and compounds
- Counting Atoms
  - Derive the number of atoms from an element's mass
  - Derive the number of molecules and atoms from the mass of a compound
- Calculating Mass Percent Compositions
  - Calculate the percent composition of a compound given mass of components
  - Calculate percent composition from molecular formula
- Calculating Empirical Formulas
  - Determine an empirical formula from the masses of a compound's elements
  - Determine an empirical formula from the percent composition of a compound
- Calculating Molecular Formulas
  - Derive a molecular formula for a compound from percent composition and molecular mass

#### Chapter 7. Chemical Reactions

- Identifying Chemical Reactions
  - Identify and describe chemical reactions
- Writing and Balancing Chemical Equations
  - Understand how to represent chemical reactions using an equations
  - Write and balance chemical reactions
- Precipitation Reactions and Solubility Rules
  - Understand solubility rules and precipitation reactions
- Chemical Equations For Ionic Reaction in Solution
  - Write and balance equations for ionic reactions
- Acid—Base and Gas Evolution Reactions
  - Write balanced chemical equations for acid-base reactions
  - Write the chemical equation for a gas evolution reaction
- Oxidation—Reduction Reactions
  - Understand oxidation and reduction
- Classifying Chemical Reactions
  - Classify chemical reactions

#### Chapter 8. Quantities in Chemical Reactions

- Introduction to Stoichiometry
  - Calculate the molar ratios from balanced equations
- Mole-Mole and Mass-Mass conversions
  - Calculate the number of moles of a reactant required given moles of the other reactant(s) and a balanced equation
  - Calculate the number of product moles generated by a reaction
  - Calculate the mass of a product or a reactant given a balanced chemical equation
- Limiting Reactants, Theoretical Yields, and Percent Yields
  - Identify limiting reactants
  - Calculate theoretical yields and percent yields of reactions given masses of reactants and products

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- Enthalpy

- Define and calculate enthalpy

#### Chapter 9. Electrons in Atoms and the Periodic Table

- The Electromagnetic Spectrum
  - Understand electromagnetic radiation
  - Determine wavelength, and frequency, and place in the electromagnetic spectrum
- The Bohr Model
  - Understand the Bohr atomic model
  - Calculate the energy of electrons in Bohr orbits
- Orbitals and Electron Configuration
  - Define and describe quantum numbers
  - Describe electron configurations of atoms
  - Interpret orbital diagrams
- Electron Configurations and the Periodic Table
  - Distinguish between valence and core electrons
  - Determine the electron configuration of an element
  - Write the electron configuration of an ion
- Periodic Trends: Atomic Size and Ionization Energy
  - Recognize variations in covalent radii by using periodic trends
  - Recognize variations in ionic radii by using periodic trends
  - Recognize variations in ionization energies by using periodic trends

#### Chapter 10. Chemical Bonding

- Lewis Structures: Representing Valence Electrons with Dots
  - Read and draw Lewis structures for an atom
  - Represent an ionic compound using a lewis structure
- Covalent Lewis Structures: Shared Electrons
  - Understand how to represent triple and double bonds when drawing Lewis structures
  - Understand how to use the octet rule to draw Lewis structures for covalent compounds
  - Identify octet rule exceptions
- Resonance: Equivalent Lewis Structures for the Same Molecule
  - Recognize resonance structures
- VSEPR and Molecular Shapes
  - Understand how to use VSEPR theory to determine molecular shape
  - Compare and contrast molecular structure and electron-pair geometry
  - Predict molecular structure and electron-pair geometry using VSEPR theory
- Electronegativity and Polarity
  - Determine the type of bond by evaluating electronegativity
  - Understand the role that molecular geometry plays in the polarity of a compound

#### Chapter 11. Gases

- The Kinetic Molecular Theory
  - Understand postulates of the kinetic molecular theory of gases
- Gas Pressure
  - Define pressure and pressure relationships
  - Understand the units of pressure and convert between them
- The Gas Laws

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  - Perform calculations with Gay-Lussac's Law

- Perform calculations with Charles's Law
- Perform calculations with Boyle's Law
- Avogadro's Law: Volume and Moles
  - Perform calculations using Avogadro's law
- The Ideal Gas Law: Pressure, Volume, Temperature, and Moles
  - Apply the ideal gas law in calculations
  - Calculate molar masses of a gases
- Mixtures of Gases
  - Perform calculations with Dalton's Law
  - Calculate the pressure when a gas is collected over water
- Stoichiometry with Gases
  - Determine the amount of product from a chemical reaction of gases

#### Chapter 12. Liquids, Solids, and Intermolecular Forces

- Properties of Liquids and Solids
  - Compare and contrast intermolecular and intramolecular forces
  - Compare and contrast properties of liquids and solids
- Intermolecular Forces in Liquids
  - Define, identify, and describe viscosity
  - Identify cohesive forces and adhesive forces in nature
  - Identify surface tension in nature
- Evaporation and Condensation
  - Define and describe condensation and vaporization
  - Define boiling point and describe its changes at various pressures
  - Calculate heat required to vaporize a liquid
  - Calculate the heat released or absorbed during phase changes
- Melting, Freezing, and Sublimation
  - Compare and contrast the properties of freezing and melting
  - Compare and contrast the properties of deposition and sublimation
- Types of Intermolecular Forces
  - Define, identify, and describe dispersion forces
  - Define, identify, and describe dipole-dipole attractions between molecules
  - Define, identify, and describe hydrogen bonding
- Types of Crystalline Solids: Molecular, Ionic, and Atomic
  - Distinguish between types of solids: ionic, metallic, covalent network, and molecular

#### Chapter 13. Solutions

- Solutions and Solubility
  - Describe the characteristics of a solution
  - Describe the formation and properties of solutions
  - Explain the differences between saturated, unsaturated, and supersaturated
- Electrolyte Solutions
  - Describe the characteristics of ionic electrolytes
- Solutions of Gases in Water
  - Describe the properties of solutions of gases in liquids and understand Henry's law
- Mass Percent and Molality

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  - Calculate the mass percentage of a component of a solution

- Calculate molality and mole fraction
- Solution Dilution
  - Calculate the volume of stock solution needed to reach a given dilution
- Solution Stoichiometry
  - Solve stoichiometry problems with reactants in solution
- Freezing Point Depression and Boiling Point Elevation
  - Identify and define colligative properties
  - Determine solution boiling points
  - Determine solution freezing points
- Osmosis and Osmotic Pressure
  - Understand osmotic pressure

#### Chapter 14. Acids and Bases

- Introduction to Acids and Bases
  - Identify acids and bases given physical properties and recognize common acids and bases
- Bronsted Lowry Acids and Bases
  - Identify acids and bases using the Bronsted-Lowry definition
  - Read and write equations for the self ionization of water and for acid and base ionization reactions
- Reactions of Acids and Bases
  - Identify types of reactions involving acids and bases
- The pH and pOH Scales
  - Calculate concentrations of hydronium and hydroxide ions
  - Classify solutions as an acidic, basic, or neutral based on pH or hydronium/hydroxide concentrations
  - Identify hydronium and hydroxide concentrations on the pH and pOH scales
  - Perform calculations that relate pH and pOH
- Acid-Base Titrations
  - Interpret and understand titration curves
  - Calculate the pH associated with an acid base titration
- Strong and Weak Acids and Bases
  - Explain  $K_a$  and acid strength
  - Explain  $K_b$  and base strength
  - Explain the relationship between conjugate acid-base pairs
  - Explain the ionization of weak acids and weak bases
- Buffers
  - Explain buffers and how they work

#### Chapter 15. Chemical Equilibrium

- Rate of a Chemical Reaction and the Collision Theory
  - Define reaction rate
  - Define collision theory
- Factors Affecting Reaction Rates
  - Explain how the rates of reactions are impacted by the intensive properties of participating reactants

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  - Explain how concentration and temperature of reactant affects the rate of reaction

- Dynamic Chemical Equilibrium
  - Describe the features of chemical equilibria
  - Write and understand reaction quotient expressions
- Types of Equilibria and the Equilibrium Constant
  - Determine equilibrium constants
  - Compare heterogeneous and homogeneous equilibria
- Calculating and Using Equilibrium Constants
  - Calculate equilibrium constants
  - Calculate a concentration using an equilibrium constant
  - Calculate changes in concentration in equilibrium reactions
- Le Châtelier's Principle: Effects of Pressure, Temperature, and Concentration on Equilibria
  - Understand the effect that changes in concentration have on equilibrium
  - Understand the effect that changes in pressure have on equilibrium
  - Understand the effect that changes in temperature have on equilibrium
- The Solubility-Product Constant
  - Write equations for solubility products
  - Calculate  $K_{sp}$  values
  - Perform calculations using  $K_{sp}$  values
  - Calculate the solubility of a molecule using  $K_{sp}$  values
- Activation Energy and Catalysts
  - Calculate activation energy using the Arrhenius equation
  - Define and identify catalysts

#### Chapter 16. Oxidation and Reduction

- Oxidation and Reduction
  - Explain the fundamentals of electrochemistry
  - Determine the oxidation state of each atom in a molecule
- Balancing Redox Equations
  - Balance oxidation-reduction reactions under acidic conditions
  - Balance oxidation-reduction reactions under basic conditions
- Predicting Spontaneous Redox Reactions
  - Determine if a redox reaction will occur spontaneously
- Batteries and Fuel Cells
  - Explain galvanic cells
  - Explain the features of primary batteries and how they work
  - Explain the features of secondary batteries and how they work
  - Explain the features of fuel cells and how they work
- Electrolysis
  - Describe electrolysis and electrolytic cells
  - Describe electrolysis of solutions
- Corrosion
  - Describe corrosion and identify examples

#### Chapter 17. Radioactivity and Nuclear Chemistry

- Nuclear Structure and Stability
    - Understand the fundamentals of nuclear chemistry
    - Describe nuclear binding energy and perform calculations
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- Explain stability of nuclei
- Nuclear Equations
  - Compare the characteristics of the types of particles in nuclear reactions
  - Write and balance equations for alpha, beta, positron, and gamma decay
- Radioactive Decay
  - Compare and contrast alpha, beta, gamma, and positron radiation
  - Calculate half-lives of radioactive substances
  - Understand how to determine the age of an object by using radioisotopes
- Transmutation and Nuclear Energy
  - Explain the synthesis of nuclides and transmutation
  - Describe nuclear fission
  - Understand the operation of a nuclear power plant
  - Describe nuclear fusion

#### Chapter 18. Organic Chemistry

- Distinguishing between Organic and Inorganic
  - Compare and contrast properties of organic and inorganic compounds
- Hydrocarbons
  - Distinguish between the various types of hydrocarbons and describe their basic properties
- Alkanes: Saturated Hydrocarbons
  - Recognize chemical and physical properties of alkanes
  - Identify and draw isomers of alkanes
  - Understand how to name alkanes and write their formulas
- Alkenes and Alkynes
  - Name and write formulas for alkenes, recognize physical properties of alkenes, and identify their isomers
  - Name and write formulas for alkynes and their recognize physical properties
- Hydrocarbon Reactions
  - Write balanced equations for reactions involving alkanes
  - Write balanced equations for reactions involving alkenes and alkynes
- Aromatic Hydrocarbons
  - Name and write formulas for aromatic compounds and recognize their physical and chemical properties
- Alcohols
  - Identify the characteristics and properties of alcohols
- Ethers
  - Recognize chemical and physical properties of ethers
- Aldehydes and Ketones
  - Identify the characteristics of ketones and aldehydes
- Carboxylic Acids and Esters
  - Explore the structure and nomenclature of carboxylic acids
  - Distinguish an ester from other functional groups and explore nomenclature of ester compounds
- Amines

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  - Explore the structural basis and nomenclature of amines

- Polymers
  - Define polymers, describe their chemical properties, and identify examples of them in the modern world

#### Chapter 19. Biochemistry

- The Cell and Its Main Chemical Components
    - Describe the basic structure of cells
  - Carbohydrates: Sugar, Starch, and Fiber
    - Understand the basic structure of different carbohydrates and their biological importance
  - Lipids
    - Understand lipid diversity and distinguish between the lipids as a group and the polymers
    - Identify the carboxyl group and the hydrocarbon chain in a fatty acid and distinguish between saturated and unsaturated fatty acids
  - Proteins and Amino Acids
    - Identify the structural components of an amino acid and understand the chemical diversity of amino acids
  - Protein Structure
    - Distinguish between the different levels of protein structure, including primary, secondary, tertiary, and quaternary
  - Nucleic Acids
    - Identify the three components of nucleotides and distinguish between purines and pyrimidines
  - DNA Structure
    - Understand the complementarity of the DNA double helix
-