

Chemistry

Chemistry is a physical science course that focuses on the properties and behavior of matter. The concepts explored in chemistry are fundamental to understanding all areas of science and the components of the universe at both the microscopic and macroscopic levels. Chemistry encompasses both qualitative and quantitative analysis of scientific processes, supported by inquiry-based learning and laboratory experiences.

In Chemistry, students use the academic language of science in context to communicate claims, evidence, and reasoning for chemical phenomena. The course provides in-depth investigations of the properties and interactions of matter, allowing students to acquire prerequisite skills for postsecondary studies and careers in science, technology, engineering, and mathematics (STEM) fields. External resources, including evidence-based research published in scientific journals, should be utilized to provide students with a broad scientific experience which will adequately prepare them for college, careers, and citizenship.

Content standards within this course are organized according to three of the disciplinary core ideas for physical science. The first core idea, “Matter and Its Interactions,” deals with the substances and processes encompassing our universe on microscopic and macroscopic levels. The second core idea, “Motion and Stability: Forces and Interactions,” concentrates on forces and motion, types of interactions, and stability and instability in chemical systems. The third core idea, “Energy,” involves conserving energy, energy transformations, and energy applications to everyday life.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon ⚙️. Through guided participation in the engineering design process, students will design and conduct experiments to evaluate the effect of solute concentration on the colligative properties of a solution.

Although not included as discrete standards, these scientific practices should be embedded throughout the course:

- Measurement - Choose appropriate tools and record measurements with the correct number of significant figures to show measured and estimated digits and units.
- Significant figures - Record the correct number of significant figures after performing mathematical calculations with the data.
- Dimensional analysis - Perform unit conversions using dimensional analysis, including conversions of derived units such as g/cm^3 and molar conversions.
- Scientific notation - Use scientific notation to report very large or small quantities with the correct number of significant figures, and carry out multiplication, division, addition, and subtraction calculations with scientific notation.
- Graphing - Create graphs to determine and communicate relationships between variables and analyze graphs to make predictions about unknown data points.

Each content standard completes the stem “*Students will...*”

Matter and Its Interactions		
Structure and Properties	1. Use the periodic table as a model to predict the structure and properties of atoms and elements.	Patterns
	a. Assess the merits and limitations of historic and modern atomic models pertaining to the presence, position, mass, and charge of subatomic particles. b. Develop and use models of an element’s subatomic particles to compare and contrast its atoms, ions, and isotopes.	Structure and Function
	c. Analyze and interpret data to identify or describe an element based on its number of protons, its relative abundance of isotopes, its organization and placement of electrons, and its light emission spectrum. <i>Examples: average atomic mass, electron configuration, orbital notation, noble-gas notation, photoemission spectroscopy</i>	Cause and Effect
	d. Ask questions to determine the relationship between an element’s physical and chemical properties and its position on the periodic table. <i>Examples: density, melting point, chemical hardness; reactivity, chemical stability, oxidation state</i> e. Construct explanations of how periodic trends can be used to predict the properties of elements. <i>Examples: atomic radii, ionization energy, electronegativity</i>	Patterns

Motion and Stability: Forces and Interactions

Atomic and Molecular Interactions	2. Construct explanations of the formation of intramolecular and intermolecular forces and their effects on atomic and molecular interactions.	Structure and Function
	a. Develop and use Lewis dot diagrams to model the formation of covalent and ionic bonds.	Systems and System Models
	b. Construct an explanation of the change in potential energy that occurs when chemical bonds are formed.	Cause and Effect
	c. Plan and carry out an investigation to identify specific physical and chemical properties of compounds formed from ionic, covalent, and metallic bonding. <i>Examples: melting point, boiling point, density, solubility, state of matter, electrical conductivity; flammability, toxicity</i>	Scale, Proportion, and Quantity
	d. Develop and use models based on valence shell electron pair repulsion (VSEPR) theory to predict the shape of a molecule up to four electron domains around the central atom.	Systems and System Models
	e. Construct an explanation of the polarity of a molecule based on electronegativity data and molecular geometry. f. Analyze and interpret data from the periodic table to derive chemical formulas and names for ionic and covalent compounds.	Patterns
	g. Analyze and interpret data to compare the strengths of intermolecular forces and to explain how these forces affect physical properties. <i>Examples: dipole-dipole interactions, hydrogen bonding, London dispersion forces</i>	Structure and Function

Matter and Its Interactions: Energy

Chemical Reactions	3. Develop and use multiple types of models to represent chemical reactions.	Systems and System Models
	a. Use qualitative and quantitative reasoning to describe and balance chemical equations to satisfy the law of conservation of matter. <i>Examples: describe differences in properties of reactants and products</i>	Scale, Proportion, and Quantity
	b. Use qualitative and quantitative reasoning to classify chemical reactions, predict the products of single replacement and double replacement reactions, and represent chemical reactions using ionic equations.	Patterns
	c. Analyze and interpret temperature and bond energy data to classify a reaction as endothermic or exothermic.	Energy and Matter
	d. Construct an explanation, using particle diagrams and collision theory, for how particle size, concentration, and temperature affect the rate of a chemical reaction.	Stability and Change

Matter and Its Interactions

Stoichiometry	<p>4. Use stoichiometric ratios to support the claim that atoms, and therefore mass, are conserved during chemical reactions.</p> <ul style="list-style-type: none"> a. Quantitatively apply the concepts of the mole and Avogadro's number to conceptualize and calculate percent composition and empirical or molecular formulas of common compounds. b. Use mathematical representations of the mole concept to solve reaction stoichiometry problems, involving mole-to-mole conversions, mass-to-mole conversions, and mass-to-mass conversions. 	Scale, Proportion, and Quantity
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	<ul style="list-style-type: none"> c. Use mathematical models to reveal the relationships among the theoretical, actual, and percent yields of chemical reactions. d. Qualitatively and quantitatively determine the limiting reactant when given the masses of all reactants. e. Use mathematics and computational thinking to perform gas stoichiometry calculations involving mass, volume, and number of moles at standard temperature and pressure (STP). 	
Solutions	5. Obtain, evaluate, and communicate information concerning factors that affect solubility and the properties of solutions. <ul style="list-style-type: none"> a. Use mathematics and computational thinking to express the concentrations of given solutions in terms of molarity and molality. 	
	<ul style="list-style-type: none"> b. Develop and use models to illustrate solute-solvent interactions. <i>Example: particle diagram</i> 	Structure and Function
	<ul style="list-style-type: none"> c. Use mathematics and computational thinking to prepare solutions from both solids and concentrated solutions when given a desired molarity and volume. 	Scale, Proportion, and Quantity
	<ul style="list-style-type: none"> d. Analyze and interpret data to explain the effects of temperature on the solubility of solid, liquid, and gaseous solutes in a solvent and the effects of pressure on the solubility of gaseous solutes. e. ⚙️ Design and conduct experiments to evaluate the effect of solute concentration on the colligative properties of a solution. <i>Examples: boiling point, freezing point, vapor pressure</i> 	Cause and Effect
Acids and Bases	6. Make qualitative and quantitative claims, based on ion concentration, about the acidic, basic, or neutral characteristics of a solution. <ul style="list-style-type: none"> a. Obtain, evaluate, and communicate information concerning the properties of acids and bases. b. Use the periodic table and computational thinking to derive chemical formulas and names of acids and bases. 	Patterns

	<p>c. Use multiple models to predict the relative properties of strong, weak, concentrated, and dilute acids and bases. <i>Examples: Arrhenius and Brønsted-Lowry acids and bases</i></p>	Structure and Function
	<p>d. Use mathematics to calculate the pH, pOH, $[\text{OH}^-]$, and $[\text{H}_3\text{O}^+]$ of common solutions. e. Plan and carry out a strong acid-strong base titration to determine the concentration of an unknown acidic or basic solution.</p>	Scale, Proportion, and Quantity
Energy		
Gases	<p>7. Plan and carry out investigations to determine how the atomic and molecular motion in chemical and physical processes is related to the kinetic molecular theory.</p> <p>a. Qualitatively and quantitatively relate changes in the temperature and pressure of a gas to particle motion and number of collisions.</p> <p>b. Express the relationship among pressure, volume, temperature, and the number of moles of a gas quantitatively, conceptually, and graphically. <i>Examples: Boyle's Law, Charles's Law, Dalton's Law of Partial Pressures, Ideal Gas Law</i></p>	Cause and Effect