

Unit	Lesson	Lesson Objectives
Matter		
Changes in Matter		
Differentiate between extensive and intensive properties of matter, and give examples of each.		
Differentiate between physical changes and chemical changes of matter.		
Differentiate between physical properties and chemical properties of matter.		
Science Practice: Identify substances based on their chemical and physical properties.		
Lab: Physical and Chemical Changes		
Conduct systematic observations during an experiment.		
Describe indicators of chemical change.		
Distinguish between chemical changes and physical changes.		
Science Practice: Write a clear, coherent laboratory report that describes methods used and conclusions made.		
Elements, Compounds, and Mixtures		
Describe compounds as pure substances.		
Describe elements as pure substances.		
Describe mixtures.		
Science Practice: Classify matter as pure substances or mixtures by studying their properties.		
Mixtures and Solutions		
Describe heterogeneous mixtures, including suspensions and colloids.		
Describe homogeneous mixtures, such as solutions.		
Identify nonaqueous solutions.		
Identify the components of a solution.		
Science Practice: Build vocabulary by properly using the terms <i>mixture</i> , <i>solution</i> , <i>solute</i> , and solvent.		
Solutions and Solubility		
Define solubility and differentiate between saturated, supersaturated, and unsaturated solutions.		
Describe the dissolving process on the molecular level.		
Identify factors affecting the rate at which a substance dissolves.		
Investigate factors that influence solubility.		
Science Practice: Interpret, analyze, and make inferences from solubility graphs.		
Lab: Solubility		
Accurately read the temperature in °C to know how temperature affects saturation.		
Formulate an investigative question to scientifically investigate how temperature affects solubility.		
Investigate how the temperature of a solvent affects the solubility of a solid.		
Science Practice: Plan and carry out an investigation to test factors affecting solubility.		

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Atoms and the Periodic Table**The Structure of the Atom**

Describe the structure of atoms, and discriminate between the relative sizes and electrical charges of protons, neutrons, and electrons.

Explain that protons and neutrons have substructures and consist of particles called quarks.

Explain the relationship between the number of neutrons in an atom of an element, its mass number, and its isotopes.

Identify an element based on the number of protons in an atom.

Science Practice: Use math to calculate the average atomic mass of an element from its isotopic composition.

The Historical Development of Atomic Theory

Describe early atomic models including Dalton's postulates.

Describe how Rutherford's gold foil experiment led to Rutherford's nuclear model of the atom.

Describe how Thomson's and Millikan's research led to the understanding of the electron in the early atomic model.

Science Practice: Describe, in writing, how a scientist's creativity resulted in changes in atomic theory.

The Modern Atomic Theory

Describe the experimental basis for Einstein's explanation of the photoelectric effect.

Describe the modern (electron cloud) model of the atom.

Explain Bohr's model of the atom and how it accounts for the existence of spectral lines.

Science Practice: Compare Dalton's atomic model with the current quantum model of the atom.

Atomic Numbers and Electron Configurations

Express the arrangement of electrons of atoms using electron configurations.

Identify electron configurations as a scientific model, and explain its usefulness and limitations.

Science Practice: Use specific symbols to represent the arrangement of electrons in atoms.

Use atomic orbitals to write quantum numbers for electrons.

The History and Arrangement of the Periodic Table

Describe the arrangement of the periodic table and relate the properties of atoms to their position in the periodic table.

Outline the historical development of the periodic table.

Science Practice: Predict the properties of elements based on their position on the periodic table.

Use the periodic table to classify elements.

Electrons and the Periodic Table

Relate the position of an element in the periodic table to its electron configuration.

Science Practice: Analyze the relationship between electron configurations and the structure of the periodic table.

Use the periodic table to determine the number of valence electrons available for bonding.

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	Periodic Trends	<p>Science Practice: Given two elements, make predictions that compare their radii, ionization energy, electronegativity, and/or electron affinity.</p> <p>Use the periodic table to identify and explain periodic trends in ionization energy.</p> <p>Use the periodic table to identify trends in electronegativity and electron affinity.</p> <p>Use the periodic table to predict trends in atomic radii and ionic radii.</p>
	Chemical Bonding	
	Types of Chemical Bonds	<p>Compare and contrast ionic, metallic, and covalent bonds.</p> <p>Relate electronegativity and ionization energy to bond formation.</p> <p>Science Practice: Create a chart to compare and contrast ionic, metallic, and covalent bonds.</p>
	Ionic Bonding	<p>Describe how polyatomic ions form ionic bonds with other ions.</p> <p>Explain how ionic bonds affect the properties of ionic compounds.</p> <p>Explain how ionic bonds form.</p> <p>Explain that ionic compounds form crystal lattices.</p> <p>Science Practice: Explain the process by which ionic bonds form.</p>
	Nomenclature of Ionic Compounds	<p>Name ionic compounds using the International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules.</p> <p>Predict formulas of stable ionic compounds by balancing charges.</p> <p>Science Practice: Develop vocabulary by using IUPAC rules for naming ionic compounds.</p> <p>Write chemical formulas of ionic compounds and common polyatomic ions.</p>
	Metallic Bonding	<p>Describe how metallic bonds form.</p> <p>Describe the properties of metals including thermal conductivity, electrical conductivity, malleability, and ductility.</p> <p>Science Practice: Apply the theory of metallic bonding to explain metallic properties.</p>
	Covalent Bonding	<p>Construct electron-dot structures (i.e., Lewis structures) to illustrate the arrangement of electrons in covalent structures.</p> <p>Explain how covalent bonds affect the properties of covalent compounds.</p> <p>Science Practice: Develop and use electron-dot models, and explain their usefulness and limitations.</p> <p>Use the octet rule to predict covalent compounds.</p> <p>Use the periodic table to determine the number of electrons available for bonding.</p>

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Nomenclature of Covalent Compounds

Science Practice: Develop vocabulary by using IUPAC rules for naming covalent compounds.

Use IUPAC nomenclature rules to name and write the chemical formulas of acids and bases.

Use the International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules to write the names of covalent compounds.

Write formulas for covalent compounds and interpret those formulas in terms of composition and structure.

Lab: Ionic and Covalent Bonds

Design and conduct an experiment to test the properties of substances.

Draw conclusions about the type of bond in a substance based on the tested properties of that substance.

Science Practice: Compare your conclusions about the identity of the bonds in substances to published information about those substances.

Intermolecular Forces

Describe how hydrogen bonding and van der Waals forces affect the volatility, boiling points, and melting points of liquids and solids.

Describe hydrogen bonding.

Describe van der Waals forces, including dipole-dipole forces and London dispersion forces.

Science Practice: Give examples of intermolecular forces occurring in nature.

Chemical Reactions**Evidence of Chemical Reactions**

Explain what happens during a chemical reaction.

Identify indicators of a chemical reaction.

Science Practice: Compare scenarios to determine whether a chemical reaction has occurred.

Writing and Balancing Chemical Equations

Describe chemical reactions by writing word equations and formula equations.

Science Practice: Identify and use special symbols properly in chemical equations.

Use the law of conservation of mass to balance chemical equations.

Types of Reactions

Classify a reaction as synthesis, decomposition, single replacement, double replacement, or combustion.

Identify and characterize the types of reactions, including synthesis, decomposition, combustion, single replacement, and double replacement.

Science Practice: Predict the products of a reaction using the activity series.

Use the activity series to determine whether a single replacement reaction will occur.

Lab: Types of Reactions

Identify the reactants and products of a reaction performed in a laboratory setting.

Science Practice: Use experimental data to classify a reaction.

Write balanced equations for a reaction performed in a laboratory setting.

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		Oxidation-Reduction Define oxidation and reduction, and identify oxidized and reduced species. Follow rules to assign oxidation numbers to atoms in compounds. Identify oxidation-reduction (redox) reactions. Science Practice: Establish context by describing oxidation-reduction reactions in living and nonliving systems.
		Balancing Oxidation-Reduction Equations Science Practice: Develop the half-reaction procedure to solve scientific problems as an alternate method of balancing equations. Use the half-reaction method to balance oxidation-reduction equations. Write half-reactions for oxidation-reduction reactions.
		Reaction Rate Describe collision theory and how it is related to reactions. Explain how various factors, including concentration, temperature, and pressure, affect the rate of a chemical reaction. Explain the concept of reaction rate. Science Practice: Use the collision theory model to explain how reactions happen.
		Lab: Reaction Rate Demonstrate the effects of changing temperature and particle size on the rate of a chemical reaction. Develop reasonable conclusions in an investigation about reaction rate and generate explanations for the observed results. Science Practice: Plan and perform controlled tests of multiple variables using repeated trials during an investigation about reaction rate.
		Catalysts Compare homogeneous and heterogeneous catalysts. Explain the role that a catalyst plays in increasing reaction rate. Science Practice: Apply the effects of a catalyst to everyday examples.
		Reversible Reactions and Equilibrium Explain dynamic equilibrium. Science Practice: Use scientific notation when solving problems to find the equilibrium constant for a reaction. Write equilibrium expressions, and use them to calculate the equilibrium constant for reactions.
		Stoichiometry
		Scientific Notation and Significant Figures Science Practice: Solve science-related math problems using scientific notation with the correct number of significant figures. Use appropriate numbers of significant figures for calculated data. Write measurements in scientific notation.

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		Dimensional Analysis Explain how dimensional analysis works. Science Practice: Convert between units using dimensional analysis. Solve scientific problems using dimensional analysis.
		Molar Masses Define a mole and explain its role in the measurement of matter. Determine the molar mass of a molecule from its chemical formula. Explain the relationship between the mole and Avogadro's number. Science Practice: Perform math calculations to determine the number of particles in a given sample of a substance.
		Introduction to Stoichiometry Perform stoichiometric calculations to determine the mole-to-mole relationships between reactants and products of a reaction. Science Practice: Use mathematical procedures, including dimensional analysis and significant figures, when solving mole-to-mole stoichiometry problems. Use a balanced equation to write mole ratios correctly to use in stoichiometry problems.
		Stoichiometric Calculations Identify and solve stoichiometric problems that relate mass to moles and mass to mass. Perform stoichiometric calculations to determine mass relationships between reactants and products of a reaction. Science Practice: Use mathematical procedures, including dimensional analysis and significant figures, when solving mole-to-mass, mass-to-mole, and mass-to-mass stoichiometric problems. Use molar mass to write conversion factors that convert between mass and moles.
		Limiting Reactant and Percent Yield Calculate the percent yield of a reaction. Identify the limiting and excess reactants for a given reaction. Science Practice: Use mathematical procedures, including dimensional analysis and significant figures, when solving limiting reactant and percent yield stoichiometry problems. Use the limiting reactant to predict the theoretical yield of a reaction.
		Measures of Concentration: Molarity Calculate the concentration of solutions in units of molarity. Define concentration. Science Practice: Use mathematics and computational thinking to solve problems involving molarity. Solve stoichiometry problems involving molarity. Use molarity to calculate dilutions of solutions.

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States of Matter		
Gases		
Describe how kinetic-molecular theory explains the properties of gases, including temperature, pressure, compressibility, and volume.		
Describe the postulates of kinetic-molecular theory.		
Interpret the behavior of ideal gases in terms of kinetic-molecular theory, including diffusion and effusion.		
Science Practice: Identify the limitations of kinetic-molecular theory.		
Liquids		
Describe how kinetic-molecular theory explains the properties of liquids, including compressibility and shape.		
Describe how the postulates of kinetic-molecular theory apply to liquids.		
Science Practice: Use the kinetic-molecular theory model to explain the behavior of liquids.		
Solids and Plasmas		
Describe how kinetic-molecular theory explains the properties of plasmas.		
Describe how kinetic-molecular theory explains the properties of solids, including compressibility, shape, and volume.		
Science Practice: Give examples of plasmas in nature and technology.		
Use kinetic-molecular theory to compare and contrast atomic or molecular motion in solids and plasmas.		
Phase Changes		
Describe phase changes in terms of kinetic-molecular theory.		
Describe the energy changes that happen during changes of state.		
Science Practice: Make and interpret graphs of temperature vs. time for changes of state.		
Gas Laws		
Apply Dalton's law of partial pressures to describe the composition of gases.		
Define partial pressure.		
Derive the combined gas law from Boyle's law, Charles's law, and Gay-Lussac's law.		
Science Practice: Make a table to compare the various gas laws.		
State Boyle's law, Charles's law, and Gay-Lussac's law, and apply these laws to calculate the relationships among volume, temperature, and pressure.		
Lab: Charles's Law		
Calculate relationships between volume and temperature according to Charles's law.		
Perform an investigation that demonstrates the relationship between the volume and temperature of a gas.		
Science Practice: Analyze and interpret data gathered in an investigation about Charles's law.		
Lab: Boyle's Law		
Calculate relationships between volume and pressure according to Boyle's law.		
Perform an investigation that demonstrates the relationship between the volume and pressure of a gas.		
Science Practice: Obtain, evaluate, and communicate information gathered in an investigation about Boyle's law.		

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The Ideal Gas Law		
<p>Explain how Avogadro's law, or principle, can be combined with other gas laws to describe the relationships among pressure, temperature, volume, and number of moles of a gas.</p> <p>Science Practice: Use math to solve ideal gas law problems.</p> <p>Solve problems using the ideal gas law.</p> <p>State the ideal gas law, which relates pressure, temperature, and volume of an ideal gas.</p>		
Thermodynamics		
Energy		
<p>Describe the law of conservation of energy.</p> <p>Differentiate among the various forms of energy, including kinetic energy, potential energy, chemical energy, and thermal energy.</p> <p>Explain that energy can be transformed from one form to another.</p> <p>Science Practice: Integrate concepts from both chemistry and physics to analyze energy transformations and the conservation of energy.</p>		
Heat		
<p>Describe heat flow in terms of the motion of atoms or molecules.</p> <p>Distinguish between exothermic chemical processes and endothermic chemical processes.</p> <p>Relate temperature to the average molecular kinetic energy.</p> <p>Science Practice: Analyze and interpret information about a reaction to classify the reaction as either an exothermic process or an endothermic process.</p>		
Calorimetry		
<p>Define calorimetry and explain how calorimeters work.</p> <p>Differentiate between heat capacity and specific heat.</p> <p>Science Practice: Perform mathematical calculations involving heat, mass, temperature change, and specific heat.</p> <p>Solve problems involving heat flow and temperature changes to calculate the specific heat of a substance.</p> <p>Use calorimetry to calculate the heat of a chemical process.</p>		
Lab: Calorimetry and Specific Heat		
<p>Demonstrate safe laboratory practices while using a calorimeter.</p> <p>Determine the specific heat of a metal using a calorimeter.</p> <p>Identify possible sources of procedural and mathematical errors in an experiment.</p> <p>Science Practice: Precisely follow a multistep procedure to build and use a calorimeter.</p> <p>Systematically collect, organize, record, and analyze data.</p>		
Thermochemical Equations		
<p>Science Practice: Examine books and other sources of information to find standard enthalpies of formation to solve thermochemical problems.</p> <p>Understand the use of enthalpy in thermochemistry.</p> <p>Use thermochemical equations to calculate energy changes (i.e., enthalpy changes) that occur in a chemical reaction.</p> <p>Use thermochemical equations to calculate energy changes (i.e., enthalpy changes) that occur in a combustion reaction.</p>		

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Enthalpy and Phase Changes

Analyze conceptually the flow of energy during changes of state (phase).

Analyze quantitatively the flow of energy during changes of state (phase) using the molar enthalpies (heats) of fusion, solidification, vaporization, and condensation.

Science Practice: Use appropriate scientific tools and techniques to gather and analyze data.

Enthalpy of Reaction

Apply Hess's law to calculate enthalpy change in a reaction.

Demonstrate how to produce an overall chemical equation from equations for intermediate reaction steps.

Science Practice: Translate quantitative information expressed in words in a text into a visual form by drawing enthalpy diagrams.

Lab: Enthalpy

Collect data with accuracy and precision, and organize the data while doing repeated trials in an experiment about enthalpy and entropy.

Determine the enthalpy change in a reaction by applying Hess's law.

Know specific hazards of chemical substances used in an experiment about enthalpy and entropy as summarized on the MSDS.

Science Practice: Develop reasonable conclusions about changes in enthalpy based on data collected.

Select and use appropriate tools to gather and analyze data during an experiment about enthalpy and entropy.

Enthalpy, Entropy, and Free Energy

Compare spontaneous and nonspontaneous reactions.

Define free energy and use the Gibbs free energy equation to determine whether a reaction is spontaneous.

Describe and give examples of entropy.

Differentiate "enthalpy" and "entropy" and describe how enthalpy and entropy affect a reaction's spontaneity.

Science Practice: Use mathematics to solve problems involving the Gibbs free energy equation.

Acids and Bases

Properties of Acids and Bases

Describe applications of acids and bases.

Describe the observable properties of acids.

Describe the observable properties of bases.

Science Practice: Determine the meaning of the key terms *acid* and *base* as they are used in chemistry.

Arrhenius, Bronsted-Lowry, and Lewis Acids and Bases

Describe the Arrhenius definitions of acids and bases.

Describe the Bronsted-Lowry definitions of acids and bases.

Describe the Lewis definitions of acids and bases.

Identify conjugate acids and conjugate bases in a Bronsted-Lowry acid-base reaction.

Science Practice: Describe how Arrhenius's, Bronsted's, Lowry's, and Lewis's competing interpretations of the same evidence are useful in different ways.

Unit	Lesson	Lesson Objectives
	pH	<p>Convert between pH and hydrogen ion concentration, and between pOH and hydroxide ion concentration.</p> <p>Convert between pH and pOH, and between hydrogen ion concentration and hydroxide ion concentration.</p> <p>Define pH and pOH.</p> <p>Describe the self-ionization of water.</p> <p>Science Practice: Solve scientific problems involving pH using logarithmic functions.</p> <p>Use the pH scale to characterize the acidity and basicity of solutions.</p> <p>Lab: Measuring pH</p> <p>Create a universal pH indicator using an everyday material.</p> <p>Measure the pH of various substances using a universal indicator and its key.</p> <p>Science Practice: Calibrate the scale for a pH indicator by comparing it to data measured using a known scale.</p> <p>Neutralization Reactions</p> <p>Define salt and describe the observable properties of salts and salt solutions.</p> <p>Predict the products of acid-base neutralization reactions.</p> <p>Science Practice: Use domain-specific symbols to correctly write net ionic equations.</p> <p>Write equations and net ionic equations for neutralization reactions.</p> <p>Titration Reactions</p> <p>Describe how to measure pH with indicators and meters.</p> <p>Describe the steps of the titration process.</p> <p>Explain the use of titration in chemistry.</p> <p>Science Practice: Construct an explanation of what happens during the titration process, and describe why each step of a titration is performed.</p> <p>Lab: Titration</p> <p>Determine the concentration of an acid using titration.</p> <p>Science Practice: Use designated laboratory techniques to perform a titration.</p> <p>Select and properly use tools to perform a titration.</p>

Organic Chemistry

Organic Compounds

Describe carbon's unique bonding characteristics that make the diversity of carbon compounds possible.

Explain the difference between structural isomers and geometric isomers.

Read and draw structural formulas of organic compounds.

Science Practice: Use different models to represent the same idea (ball-and-stick models, space-filling models, and structural formulas) and explain the usefulness and limitations of each kind of model.

Unit	Lesson	Lesson Objectives
Properties and Uses of Saturated Hydrocarbons		
Describe the properties of straight-chain alkanes, branched-chain alkanes, and cycloalkanes.		
Identify uses of saturated hydrocarbons.		
Science Practice: Build vocabulary knowledge by learning how to name hydrocarbons.		
Use the system for naming the ten simplest linear hydrocarbons and isomers that contain single bonds.		
Properties and Uses of Unsaturated Hydrocarbons		
Describe the properties of alkenes, alkynes, and aromatic hydrocarbons.		
Identify uses of unsaturated hydrocarbons including uses in pharmaceuticals, petrochemicals, plastics, and food.		
Science Practice: Describe different alkenes and alkynes that can be found in nature.		
Use the system for naming the ten simplest linear hydrocarbons and isomers that contain double bonds, triple bonds, and benzene rings.		
Functional Groups		
Describe uses and natural occurrences of compounds containing functional groups.		
Identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.		
Science Practice: Translate technical information expressed in words in a text about functional groups into a visual form, such as a chart.		
Organic Reactions		
Compare addition polymerization and condensation polymerization.		
Explain that large molecules (polymers) are formed by repetitive combinations of simple subunits.		
Identify substitution, addition, condensation, and elimination reactions.		
Science Practice: Construct explanations on how polymers form.		
Nuclear Chemistry		
The Nucleus		
Differentiate chemical and nuclear reactions in terms of energy released.		
Explain how protons and neutrons in the nucleus are held together by nuclear forces.		
Explain why Einstein's equation $E = mc^2$ is used to determine the nuclear binding energy.		
Identify some naturally occurring isotopes of elements that are radioactive.		
Science Practice: Analyze a sequence (i.e., radioactive decay) that is characteristic of natural phenomena.		
Types of Radioactive Decay		
Differentiate between chemical reactions and nuclear reactions.		
Identify types of radioactive decay.		
Science Practice: Translate technical information expressed in words in a text about nuclear radiation into a visual form, such as a table, to compare the different types of radiation.		
Balancing Nuclear Reactions		
Balance nuclear equations by balancing both mass and atomic numbers.		
Science Practice: Determine the meaning of nuclide symbols and use those symbols to balance nuclear equations.		
Write symbols for nuclides using mass numbers and atomic numbers.		

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	Half-Life	<p>Calculate the amount of a radioactive substance remaining after an integral number of half-lives have passed.</p> <p>Calculate the number of half-lives that have passed given mass data for the radioactive substance.</p> <p>Describe what a half-life is.</p> <p>Science Practice: Solve scientific problems by substituting quantitative values.</p>
	Lab: Half-Life	<p>Collect, organize, and record appropriate data while doing an investigation on half-life.</p> <p>Communicate valid conclusions for a investigation modeling half-life.</p> <p>Explain how the half-life of a radioactive element is determined.</p> <p>Science Practice: Develop and use a model for studying half-life.</p> <p>Understand the concept of half-life through simulation.</p>
	Nuclear Fission and Nuclear Fusion	<p>Explain and compare fission and fusion reactions.</p> <p>Relate the role of nuclear fusion to the production of essentially all elements heavier than helium.</p> <p>Science Practice: Justify the need for peer review in science.</p>
	Nuclear Energy	<p>Describe how nuclear power plants work.</p> <p>Describe the issues surrounding nuclear waste.</p> <p>Science Practice: Weigh the merits of using nuclear energy to solve society's need for electrical energy by comparing a number of human, economic, and environmental costs and benefits.</p>
	Nuclear Radiation	<p>Describe applications of radiation.</p> <p>Describe how radiation is measured and detected.</p> <p>Explain that alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and describe the effects of each kind of radiation on living things.</p> <p>Science Practice: Describe careers that involve working with radioactive substances.</p>