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ODYSSEY Molecular Explorer

— Release 6 —

Correlation with the

Massachusetts Science Learning Standards

Chemistry, High School

Updated October 2006

Content Standards

1. Properties of Matter

Central Concept: Physical and chemical properties reflect the nature of the interactions between molecules or atoms, and can be used to classify and describe matter.

1.1 Identify and explain physical properties (e.g., density, melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances). Distinguish between chemical and physical changes.

→ **WORKSHEETS** *Chemical Matter* "Chemical and Physical Properties"

→ **WORKSHEETS** *Chemical Matter* "Identifying by Density"

1.2 Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures.

→ **CONCEPTS & APPLICATIONS** *Chemical Matter* "Examples of Elements"

→ **CONCEPTS & APPLICATIONS** *Chemical Matter* "The Types of Compounds"

→ **CONCEPTS & APPLICATIONS** *Chemical Matter* "The Types of Mixtures"

1.3 Describe the three normal states of matter (solid, liquid, gas) in terms of energy, particle motion, and phase transitions.

→ **WORKSHEETS** *Chemical Matter* "Comparing the States of Matter"

→ **WORKSHEETS** *Chemical Matter* "Side-by-Side Comparison"

⟶ **Worksheets** ***Liquids & Solids*** "Molecular Motion in the States of Matter"

⟶ **Worksheets** ***Liquids & Solids*** "The Melting Transition"

⟶ **Demos & Visuals** ***Chemical Matter*** "Physical Changes"

2. Atomic Structure and Nuclear Chemistry

Central Concepts: Atomic models are used to explain atoms and help us understand the interaction of elements and compounds observed on a macroscopic scale. Nuclear chemistry deals with radioactivity, nuclear processes, and nuclear properties. Nuclear reactions produce tremendous amounts of energy and lead to the formation of elements.

2.2 Describe Rutherford's "gold foil" experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, and electrons) of the nuclear atom and explain how they interact. .

⟶ **Worksheets** *Atoms* "Nuclei and Electrons"

2.4 Write the electron configurations for the first twenty elements of the periodic table. .

⟶ **Demos & Visuals** *Atoms* "What does a hydrogen atom look like?"

⟶ **Worksheets** *Atoms* "Atomic Orbitals" .

⟶ **Worksheets** *Atoms* "s- and p-Orbitals"

⟶ **Worksheets** *Atoms* "d-Orbitals"

3. Periodicity

Central Concepts: Repeating (periodic) patterns of physical and chemical properties occur among elements that define families with similar properties. The periodic table displays the repeating patterns, which are related to the atoms' outermost electrons.

3.1 Explain the relationship of an element's position on the periodic table to its atomic number. Identify families (groups) and periods on the periodic table.

⟶ **Concepts & Applications** *Chemical Matter* "Examples of Elements"

⟶ **Concepts & Applications** *Main Groups* "Alkali Metals"

⟶ **Concepts & Applications** *Main Groups* "Alkaline Earth Metals"

⟶ **Concepts & Applications** *Transition Metals* "d- and f-Blocks"

⟶ **Concepts & Applications** *Main Groups* "Boron Group"

⟶ **Concepts & Applications** *Main Groups* "Carbon Group"

⟶ **Concepts & Applications** *Main Groups* "Nitrogen Group"

⟶ **Concepts & Applications** *Main Groups* "Oxygen Group"

⟶ **Concepts & Applications** *Main Groups* "Halogens"

⟶ **Concepts & Applications** *Main Groups* "Noble Gases"

4. Chemical Bonding

Central Concept: Atoms bond with each other by transferring or sharing valence electrons to form compounds.

4.1 Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons.

⟶ **Worksheets** *Chemical Bonding* "Exploring Ionic Interactions"

⟶ **Worksheets** *Chemical Bonding* "Electron Sharing in Molecules"

⟶ **Worksheets** *Chemical Bonding* "Energetics of Covalent Bonding"

4.2 Draw Lewis dot structures for simple molecules and ionic compounds.

⟶ *Many Stockroom Pages*

4.3 Use electronegativity to explain the difference between polar and nonpolar covalent bonds.

⟶ **Worksheets** *Chemical Bonding* "Polar Bonds and Molecules"

⟶ **Worksheets** *Chemical Bonding* "Classifying by Bond Polarity"

4.4 Use valence-shell electron-pair repulsion theory (VSEPR) to predict the molecular geometry (linear, trigonal planar, and tetrahedral) of simple molecules.

⟶ **Worksheets** *Chemical Bonding* "VSEPR Theory"

⟶ **Worksheets** *Chemical Bonding* "Comparing Shapes for a Molecule"

4.5 Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (e.g., surface tension, capillary action, density, boiling point).

⟶ **Worksheets** *Liquids & Solids* "Structure and Dynamics of Liquid Water"

4.6 Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.

⟶ **Worksheets** *Chemical Matter* "Naming Molecular Compounds"

⟶ **Worksheets** *Chemical Bonding* "Polyatomic Ions"

5. Chemical Reactions and Stoichiometry

Central Concepts: In a chemical reaction, one or more reactants are transformed into one or more new products. Chemical equations represent the reaction and must be balanced. The conservation of atoms in a chemical reaction leads to the ability to calculate the amount of products formed and reactants used (stoichiometry).

5.1 Balance chemical equations by applying the laws of conservation of mass and constant composition (definite proportions).

⟶ **Worksheets** *Kinetics* "Examining a Reaction Mechanism"

6. States of Matter, Kinetic Molecular Theory, and Thermochemistry

Central Concepts: Gas particles move independently of each other and are far apart. The behavior of gas particles can be modeled by the kinetic molecular theory. In liquids and solids, unlike gases, particles are close to each other. The driving forces of chemical reactions are energy and entropy. The reorganization of atoms in chemical reactions results in the release or absorption of heat energy.

6.1 Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.

⟶ **Worksheets** *Gases* "The Pressure-Volume Relationship"

⟶ **Worksheets** *Gases* "The Pressure-Temperature Relationship"

⟶ **Demos & Visuals** *Gases* "What is Boyle's Law?"

⟶ **Concepts & Applications** *Gases* "Avogadro's Law"

⟶ **Concepts & Applications** *Gases* "The Universality of the Ideal Gas Law"

6.2 Perform calculations using the ideal gas law. Understand the molar volume at 273 K and 1 atmosphere (STP).

⟶ **Worksheets** *Gases* "Standard Temperature and Pressure"

⟶ **Concepts & Applications** *Gases* "The Universality of the Ideal Gas Law"

6.3 Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.

→ **WORKSHEETS** *Chemical Matter* "Comparing the States of Matter"

→ **WORKSHEETS** *Chemical Matter* "Side-by-Side Comparison"

→ **WORKSHEETS** ***Liquids & Solids*** "Molecular Motion in the States of Matter"

→ **WORKSHEETS** ***Liquids & Solids*** "The Melting Transition"

→ **DEMOS & VISUALS** ***Chemical Matter*** "Physical Changes"

6.4 Describe the law of conservation of energy. Explain the difference between an endothermic process and an exothermic process.

→ **DEMOS & VISUALS** *Thermochemistry* "Energy of a Vibrating Diatomic"

→ **WORKSHEETS** *Kinetics* "Reactive Collisions Between Molecules"

→ **WORKSHEETS** *Kinetics* "Examining a Reaction Mechanism"

→ **WORKSHEETS** *Equilibria* "Equilibrium and Temperature"

6.5 Recognize that there is a natural tendency for systems to move in a direction of disorder or randomness (entropy).

→ **DEMOS & VISUALS** ***Chemical Thermodynamics*** "Gas Expansions"

→ **DEMOS & VISUALS** *Chemical Thermodynamics* "Spontaneity and Disorder"

7. Solutions, Rates of Reaction, and Equilibrium

Central Concepts: Solids, liquids, and gases dissolve to form solutions. Rates of reaction and chemical equilibrium are dynamic processes that are significant in many systems (e.g., biological, ecological, geological).

7.1 Describe the process by which solutes dissolve in solvents.

→ **DEMOS & VISUALS** ***Solutions*** "How do salts dissolve in water?"

→ **CONCEPTS & APPLICATIONS** *Solutions* "Energetics of Solution Formation"

7.2 Calculate concentration in terms of molarity. Use molarity to perform solution dilution and solution stoichiometry.

→ **WORKSHEETS** *Solutions* "Concentration of a Dissolved Pesticide"

→ **CONCEPTS & APPLICATIONS** *Solutions* "Molarity vs. Molality"

7.5 Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).

→ **WORKSHEETS** *Kinetics* "Reactive Collisions Between Molecules"

7.6 Predict the shift in equilibrium when a system is subjected to a stress (LeChatelier's principle) and identify the factors that can cause a shift in equilibrium (concentration, pressure, volume, temperature).

→ **WORKSHEETS** *Equilibria* "Equilibrium and Temperature"

→ **WORKSHEETS** *Equilibria* "Equilibrium and Pressure"

8. Acids and Bases and Oxidation-Reduction Reactions

Central Concepts: Acids and bases are important in numerous chemical processes that occur around us, from industrial procedures to biological ones, from the laboratory to the environment. Oxidation-reduction reactions occur when one substance transfers electrons to another substance, and constitute a major class of chemical reactions.

8.1 Define the Arrhenius theory of acids and bases in terms of the presence of hydronium and hydroxide ions in water and the Bronsted-Lowry theory of acids and bases in terms of proton donors and acceptors.

→ **WORKSHEETS** *Acids & Bases* "Strong Acids"

8.2 Relate hydrogen ion concentrations to the pH scale and to acidic, basic, and neutral solutions. Compare and contrast the strengths of various common acids and bases (e.g., vinegar, baking soda, soap, citrus juice).

→ **WORKSHEETS** *Acids & Bases* "Structure and Acidity"

Mathematical Skills

Students are expected to know the content of the *Massachusetts Mathematics Curriculum Framework,* through grade 8. Below are some specific skills from the *Mathematics Framework* that students in this course should have the opportunity to apply:

✓ Construct and use tables and graphs to interpret data sets.

→ *Many Labs*

✓ Solve simple algebraic expressions.

→ *Many Labs*

✓ Convert within a unit (e.g., centimeters to meters).

→ *Many Labs*

✓ Use common prefixes such as *milli-, centi-,* and *kilo-*.

→ *Many Labs*

The following skills are not detailed in the *Mathematics Framework*, but are necessary for a solid understanding in this course:

✓ Determine the correct number of significant figures.

→ **WORKSHEETS** *Gases* "Gas Pressure"

→ **WORKSHEETS** *Solutions* "Concentration of a Dissolved Pesticide"

✓ Use the Celsius and Kelvin scales.

→ **WORKSHEETS** *Gases* "Temperature Scales in Chemistry"