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ODYSSEY Molecular Explorer
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Correlation with the
Tennessee Curriculum Standards
Secondary School Science
Approved January 25, 2008

Physical Science

Standard 1
Matter

Conceptual Strand 1
The composition and structure of matter is known, and it behaves according to principles that are generally understood.

Guiding Question 1
How does the structure of matter determine its chemical and physical properties?

Course Level Expectations

1. Explore matter in terms of its physical and chemical properties.

   → **C12** *Chemical Matter* "Types of Properties"

2. Describe the structure and arrangement of atomic particles.

   → *All Labs*

3. Characterize and classify elements based on their atomic structure.

   → **C3** *Chemical Matter* "Examples of Elements"
   → **P1** *Main Groups & Transition Metals* "Alkali Metals"
   → **P2** *Main Groups & Transition Metals* "Alkaline Earth Metals"
   → **P3** *Main Groups & Transition Metals* "Boron Group"
   → **P4** *Main Groups & Transition Metals* "Carbon Group"
   → **P6** *Main Groups & Transition Metals* "Nitrogen Group"
   → **P7** *Main Groups & Transition Metals* "Oxygen Group"

⟶ **P10** *Main Groups & Transition Metals* "Halogens"

⟶ **P11** *Main Groups & Transition Metals* "Noble Gases"

⟶ **P12** *Main Groups & Transition Metals* "Elements of the d- and f-Blocks"

4. Investigate chemical and physical changes.

⟶ **C13** *Chemical Matter* "Physical Changes"

⟶ **H20** *Liquids & Solids* "Melting Transition"

⟶ **M1** *Kinetics* "Observing a Reaction"

5. Evaluate pure substances and mixtures.

⟶ **C5** *Chemical Matter* "Types of Mixtures"

6. Distinguish between common ionic and covalent compounds.

⟶ **F11** *Chemical Bonding* "Polar Bonds and Molecules"

⟶ **F13** *Chemical Bonding* "Classifying by Bond Polarity"

⟶ **Stockroom** *Inorganic* "Top 10 Inorganics"

7. Construct chemical formulas for common compounds.

⟶ **Stockroom** *Inorganic* "Top 10 Inorganics"

⟶ **Stockroom** *Organic* "Top 10 Organics"

⟶ *Many Stockroom Pages*

8. Investigate relationships among the pressure, temperature, and volume of gases and liquids.

⟶ **G1** *Gases* "Density of Gases and Liquids"

⟶ **G2** *Gases* "Volume of Gases"

⟶ **G13** *Gases* "Pressure-Volume Relationship"

⟶ **G16** *Gases* "Pressure and Temperature"

⟶ **H3** *Liquids & Solids* "Compressibility"

10. Distinguish among acids, bases, and neutral substances.

⟶ **K1** *Acids & Bases* "Strong Acids"

⟶ **K2** *Acids & Bases* "Comparing Oxoacids"

Checks for Understanding

1. Distinguish among solids, liquids, gases, and plasmas.

⟶ **C6** *Chemical Matter* "States of Matter"

⟶ **C7** *Chemical Matter* "Comparing States Side-by-Side"

2. Describe and illustrate the physical differences among solids, liquids, and gases in terms of their mass, volume, density, shape, and particle arrangement.

⟶ **C6** *Chemical Matter* "States of Matter"

⟶ **C7** *Chemical Matter* "Comparing States Side-by-Side"

⟶ **H3** *Liquids & Solids* "Compressibility"

3. Use appropriate units to measure or calculate the mass and volume of substances.

⟶ **C12** *Chemical Matter* "Types of Properties"

6. Identify substances as homogeneous or heterogeneous mixtures.

⟶ **C5** *Chemical Matter* "Types of Mixtures"

8. List the three major subatomic particles and distinguish among their location, charges, and relative masses.

⟶ **D2** *Atoms* "Distribution of Mass in Atoms"

9. Distinguish between atomic number and atomic mass.

⟶ **D2** *Atoms* "Distribution of Mass in Atoms"

11. Identify the number of protons, neutrons, and electrons in an atom of an isotope based on its atomic number and atomic mass.

⟶ **D2** *Atoms* "Distribution of Mass in Atoms"

12. Know the chemical symbols for the common elements.

⟶ **C3** *Chemical Matter* "Examples of Elements"

⟶ **P1** *Main Groups & Transition Metals* "Alkali Metals"

⟶ **P2** *Main Groups & Transition Metals* "Alkaline Earth Metals"

⟶ **P3** *Main Groups & Transition Metals* "Boron Group"

⟶ **P4** *Main Groups & Transition Metals* "Carbon Group"

⟶ **P6** *Main Groups & Transition Metals* "Nitrogen Group"

⟶ **P7** *Main Groups & Transition Metals* "Oxygen Group"

⟶ **P10** *Main Groups & Transition Metals* "Halogens"

⟶ **P11** *Main Groups & Transition Metals* "Noble Gases"

⟶ **P12** *Main Groups & Transition Metals* "Elements of the d- and f-Blocks"

16. Classify a substance as an element or compound based on its chemical formula or symbol.

→ **C3** *Chemical Matter* "Examples of Elements"

→ **C4** *Chemical Matter* "Types of Compounds"

21. Use models to represent chemical reactions as synthesis, decomposition, single-replacement, and double-replacement.

→ **I2** *Solutions* "Process of Dissolving"

24. Observe and measure temperature changes to distinguish between endothermic and exothermic reactions.

→ **M2** *Kinetics* "Reactive Collisions"

→ **M3** *Kinetics* "Mechanism of a Reaction"

→ **N2** *Equilibria* "Equilibrium and Temperature"

25. Conduct, analyze, and communicate the results of an experiment that demonstrates the relationship between pressure and volume of a gas.

→ **G13** *Gases* "Pressure-Volume Relationship"

→ **G14** *Gases* "Boyle's Law"

State Performance Indicators

1. Distinguish among states of matter in terms of energy, volume, shape, particle arrangement, and phase changes.

→ **C6** *Chemical Matter* "States of Matter"

→ **C7** *Chemical Matter* "Comparing States Side-by-Side"

→ **H3** *Liquids & Solids* "Compressibility"

2. Name, measure, and describe the physical properties of substances.

→ **C12** *Chemical Matter* "Types of Properties"

3. Compare different types of mixtures.

→ **C5** *Chemical Matter* "Types of Mixtures"

4. Distinguish between examples of common elements and compounds.

→ **C3** *Chemical Matter* "Examples of Elements"

→ **C4** *Chemical Matter* "Types of Compounds"

6. Determine the composition of an atom and the characteristics of its subatomic particles.

→ **D2** *Atoms* "Distribution of Mass in Atoms"

7. Explain the interrelationship between pressure, temperature, and volume of gases.

→ **G13** *Gases* "Pressure-Volume Relationship"

→ **G16** *Gases* "Pressure and Temperature"

→ **G19** *Gases* "Universality of the Ideal Gas Law"

10. Classify chemical bonds in a compound as ionic or covalent.

→ **F11** *Chemical Bonding* "Polar Bonds and Molecules"

→ **F13** *Chemical Bonding* "Classifying by Bond Polarity"

12. Identify the reactants and products in a chemical equation, and balance equations using proper coefficients.

→ **M3** *Kinetics* "Mechanism of a Reaction"

15. Explain the Law of Conservation of Mass/Energy in terms of a balanced chemical equation.

→ **M2** *Kinetics* "Reactive Collisions"

16. Distinguish between endothermic and exothermic reactions.

→ **M2** *Kinetics* "Reactive Collisions"

→ **M3** *Kinetics* "Mechanism of a Reaction"

→ **N2** *Equilibria* "Equilibrium and Temperature"

17. Identify a substance as acidic, basic, or neutral based on its pH or response to an indicator or instrument.

→ **K1** *Acids & Bases* "Strong Acids"

→ **K2** *Acids & Bases* "Comparing Oxoacids"

Standard 2

Energy

Conceptual Strand 2

Various forms of energy are constantly being transformed into other types without any net loss of energy from the system.

Guiding Question 2

What basic energy related ideas are essential for understanding the dependency of the natural and man-made worlds on energy?

Course Level Expectations

3. Examine the applications and effects of heat energy.

→ **G10** *Gases* "The Meaning of Temperature"

→ **O3** *Chemical Thermodynamics* "Heat Conduction"

6. Investigate the Law of Conservation of Energy.

→ **L4** *Thermochemistry* "Vibrating Diatomic Molecule"

Checks for Understanding

6. Identify the boiling and freezing points of water in the Celsius, Fahrenheit, and Kelvin temperature scales.

→ **G8** *Gases* "Temperature Scales"

8. Investigate the relationships among kinetic, potential, and total energy within a closed system.

→ **L4** *Thermochemistry* "Vibrating Diatomic Molecule"

State Performance Indicators

4. Identify the boiling and freezing points of water using Celsius, Fahrenheit, or Kelvin scales.

→ **G8** *Gases* "Temperature Scales"

→ **P12** *Main Groups & Transition Metals* "Elements of the d- and f-Blocks"

8. Identify a scenario that illustrates the Law of Conservation of Energy.

→ **L4** *Thermochemistry* "Vibrating Diatomic Molecule"

11. Solve problems regarding heat, mass, specific heat capacity, and temperature change ($Q=mC\Delta T$).

→ **L6** *Thermochemistry* "Specific Heat"

Chemistry I

Standard 1
Atomic Structure

Conceptual Strand 1
Atomic theory is the foundation for understanding the interactions and changes in matter.

Guiding Question 1
How does the structure of matter determine its chemical and physical properties?

Course Level Expectations

3. Describe an atom in terms of its composition and electron characteristics.

→ **D5** *Atoms* "Electron Cloud of Argon"

Checks for Understanding

2. Compare the Bohr model and the quantum mechanical electron-cloud models of the atom.

→ **D5** *Atoms* "Electron Cloud of Argon"

11. Determine an atom's Lewis electron-dot structure or number of valence electrons from an element's atomic number or position in the periodic table.

→ **F15** *Chemical Bonding* "Comparing Shapes"

12. Represent an atom's electron arrangement in terms of orbital notation, electron configuration notation, and electron-dot notation.

→ **D14** *Atoms* "Orbitals of a Krypton Atom"

13. Compare s and p orbitals in terms of their shape, and order the s, p, d and f orbitals in terms of energy and number of possible electrons.

→ **D4** *Atoms* "Hydrogen Atom"

→ **D8** *Atoms* "Atomic Orbitals"

→ **D9** *Atoms* "Comparing Helium, Neon, and Argon"

→ **D10** *Atoms* "s-Orbitals"

→ **D11** *Atoms* "p-Orbitals"

State Performance Indicators

1. Compare and contrast the major models of the atom (e.g., Democritus, Thomson, Rutherford, Bohr, and the quantum mechanical model).

→ **D5** *Atoms* "Electron Cloud of Argon"

4. Determine the Lewis electron-dot structure or number of valence electrons for an atom of any main-group element from its atomic number or position in the periodic table.

→ **F15** *Chemical Bonding* "Comparing Shapes"

5. Represent an electron's location in the quantum mechanical model of an atom in terms of the shape of electron clouds (s and p orbitals in particular), relative energies of orbitals, and the number of electrons possible in the s, p, d and f orbitals.

→ **D8** *Atoms* "Atomic Orbitals"

→ **D9** *Atoms* "Comparing Helium, Neon, and Argon"

→ **D10** *Atoms* "s-Orbitals"

→ **D11** *Atoms* "p-Orbitals"

→ **D14** *Atoms* "Orbitals of a Krypton Atom"

Standard 2

Matter and Energy

Conceptual Strand 2
The properties of matter determine how it interacts with energy.

Guiding Question 2
What is the relationship between matter and energy?

Course Level Expectations

1. Investigate the characteristic properties of matter.

   → *All Labs*

2. Explore the interactions between matter and energy.

   → *Many Labs*

3. Apply the kinetic molecular theory to describe solids, liquids, and gases.

   → **H9** *Liquids & Solids* "Molecular Motion and Physical States"

4. Investigate characteristics associated with the gaseous state.

   → **G2** *Gases* "Volume of Gases"

   → **G5** *Gases* "Ability of Gases to Mix"

   → **G6** *Gases* "Gas Pressure"

Checks for Understanding

1. Identify a material as an element, compound or mixture; identify a mixture as homogeneous or heterogeneous; and/or identify a mixture as a solution, colloid or suspension.

   → **C5** *Chemical Matter* "Types of Mixtures"

2. Identify the solute and solvent composition of a solid, liquid or gaseous solution.

   → **I6** *Solutions* "Concentration of a Dissolved Pesticide"

3. Express the concentration of a solution in units of ppm, ppb, molarity, molality, and percent composition.

→ **I6** *Solutions* "Concentration of a Dissolved Pesticide"

5. Investigate factors that affect the rate of solution.

→ **I2** *Solutions* "Process of Dissolving"

9. Classify properties and changes in matter as physical, chemical, or nuclear.

→ **C12** *Chemical Matter* "Types of Properties"

10. Use calorimetry to: identify unknown substances through specific heat, determine the heat changes in physical and chemical changes, determine the mass of an object, and determine the change in temperature of a material.

→ **L6** *Thermochemistry* "Specific Heat"

11. Perform calculations on heat of solvation, heat of reaction, and heat of formation, and heat of phase change.

→ **M2** *Kinetics* "Reactive Collisions"

→ **M3** *Kinetics* "Mechanism of a Reaction"

→ **N2** *Equilibria* "Equilibrium and Temperature"

12. Use particle spacing diagrams to identify solids, liquids, or gases.

→ **C6** *Chemical Matter* "States of Matter"

→ **C7** *Chemical Matter* "Comparing States Side-by-Side"

13. Distinguish among solid, liquid, and gaseous states of a substance in terms of the relative kinetic energy of its particles.

→ **H9** *Liquids & Solids* "Molecular Motion and Physical States"

15. Graph and interpret the results of experiments that explore relationships among pressure, temperature, and volume of gases.

→ **G13** *Gases* "Pressure-Volume Relationship"

→ **G16** *Gases* "Pressure and Temperature"

16. Solve gas law problems.

→ **G19** *Gases* "Universality of the Ideal Gas Law"

State Performance Indicators

1. Distinguish among elements, compounds, solutions, colloids, and suspensions.

→ **C3** *Chemical Matter* "Examples of Elements"

→ **C4** *Chemical Matter* "Types of Compounds"

→ **C5** *Chemical Matter* "Types of Mixtures"

2. Identify properties of a solution: solute and solvent in a solid, liquid or gaseous solution; procedure to make or determine the concentration of a solution in units of ppm, ppb, molarity, molality, percent composition, factors that affect the rate of solution, and colligative properties.

→ **I2** *Solutions* "Process of Dissolving"

→ **I6** *Solutions* "Concentration of a Dissolved Pesticide"

3. Classify a solution as saturated, unsaturated, or supersaturated based on its composition and temperature and a solubility graph.

→ **I7** *Solutions* "Molarity vs. Molality"

5. Compare and contrast heat and temperature changes in chemical and physical processes.

→ **G10** *Gases* "The Meaning of Temperature"

→ **L2** *Thermochemistry* "Thermal Energy"

6. Investigate similarities and differences among solids, liquids and gases in terms of energy and particle spacing.

→ **C6** *Chemical Matter* "States of Matter"

→ **C7** *Chemical Matter* "Comparing States Side-by-Side"

7. Predict how changes in volume, temperature, and pressure affect the behavior of a gas.

→ **G13** *Gases* "Pressure-Volume Relationship"

→ **G14** *Gases* "Boyle's Law"

→ **G16** *Gases* "Pressure and Temperature"

Standard 3

Interactions of Matter

Conceptual Strand 3
Interactions between matter generate substances with new physical and chemical properties.

Guiding Question 3
What types of interactions between matter generate new substances?

Course Level Expectations

1. Investigate chemical bonding.

→ **F7** *Chemical Bonding* "Electron Sharing"

→ **F8** *Chemical Bonding* "Energetics of Covalent Bonding"

→ **F11** *Chemical Bonding* "Polar Bonds and Molecules"

→ **F13** *Chemical Bonding* "Classifying by Bond Polarity"

2. Analyze chemical and nuclear reactions.

→ **M1** *Kinetics* "Observing a Reaction"

→ **M2** *Kinetics* "Reactive Collisions"

→ **M3** *Kinetics* "Mechanism of a Reaction"

4. Explain the law of conservation of mass/energy.

→ **L4** *Thermochemistry* "Vibrating Diatomic Molecule"

Checks for Understanding

1. Determine the type of chemical bond that occurs in a chemical compound.

→ **F13** *Chemical Bonding* "Classifying by Bond Polarity"

2. Differentiate between ionic and covalent bond models.

→ **F1** *Chemical Bonding* "The Attraction Between Ions"

→ **F8** *Chemical Bonding* "Energetics of Covalent Bonding"

3. Identify the chemical formulas of common chemical compounds.

→ **Stockroom** *Inorganic* "Top 10 Inorganics"

→ **Stockroom** *Organic* "Top 10 Organics"

4. Employ a table of polyvalent cations and polyatomic ions to name and describe the chemical formula of ionic compounds.

→ **F10** *Chemical Bonding* "Polyatomic Ions"

8. Classify a chemical reaction as composition, decomposition, single replacement, double replacement, and combustion.

→ **I2** *Solutions* "Process of Dissolving"

13. Solve different types of stoichiometry problems (e.g., volume at STP to mass, moles to mass, molarity).

→ **I6** *Solutions* "Concentration of a Dissolved Pesticide"

15. Calculate the amount of heat lost or gained by a substance based on its mass, change in temperature, and specific heat during physical and chemical processes.

→ **L6** *Thermochemistry* "Specific Heat"

17. Identify a substance as an acid or base according to its formula.

→ **K1** *Acids & Bases* "Strong Acids"

→ **K2** *Acids & Bases* "Comparing Oxoacids"

18. Investigate the acidity/basicity of substances with various indicators.

→ **K4** *Acids & Bases* "pH Indicator"

State Performance Indicators

1. Analyze ionic and covalent compounds in terms of how they form, names, chemical formulas, percent composition, and molar masses.

→ **C20** *Chemical Matter* "Naming Compounds"

→ **F8** *Chemical Bonding* "Energetics of Covalent Bonding"

→ **F11** *Chemical Bonding* "Polar Bonds and Molecules"

→ **F13** *Chemical Bonding* "Classifying by Bond Polarity"

2. Identify the reactants, products, and types of different chemical reactions: composition, decomposition, double replacement, single replacement, combustion.

→ **I2** *Solutions* "Process of Dissolving"

6. Identify and solve stoichiometry problems: volume at STP to mass, moles to mass, and molarity.

→ **I6** *Solutions* "Concentration of a Dissolved Pesticide"

7. Classify substances as acids or bases based on their formulas and how they react with various indicators.

→ **K2** *Acids & Bases* "Comparing Oxoacids"

Chemistry II

Standard 1
Structure of Matter

Conceptual Strand 1
Atomic theory is the foundation for understanding the interactions and changes in matter.

Guiding Question 1
How does the structure of matter determine its chemical and physical properties?

Course Level Expectations

1. Explain and illustrate the arrangement of electrons surrounding an atom.

   ⟶ **D5** *Atoms* "Electron Cloud of Argon"

2. Relate the arrangement of electrons surrounding an atom with observed periodic trends.

   ⟶ **D9** *Atoms* "Comparing Helium, Neon, and Argon"

3. Describe the structure, shape, and characteristics of polyatomic ions, ionic and molecular compounds.

   ⟶ **F10** *Chemical Bonding* "Polyatomic Ions"

Checks for Understanding

4. Describe the arrangement of electrons in an atom using orbital diagrams, electron configuration notation, and Lewis structures**.**

   ⟶ **D4** *Atoms* "Hydrogen Atom"

   ⟶ **D8** *Atoms* "Atomic Orbitals"

   ⟶ **D10** *Atoms* "s-Orbitals"

   ⟶ **D11** *Atoms* "p-Orbitals"

   ⟶ **D14** *Atoms* "Orbitals of a Krypton Atom"

7. Describe to correlation between the principle quantum number of the valence electrons and the atomic and ionic radii, ionization energy, and electron affinities of an atom or ion.

   ⟶ **D9** *Atoms* "Comparing Helium, Neon, and Argon"

8. Use Lewis structures to illustrate the structure, shape, and characteristics of polyatomic ions, ionic and molecular compounds.

   ⟶ **F15** *Chemical Bonding* "Comparing Shapes"

   ⟶ *Many Stockroom Pages*

9. Illustrate the shape of molecular compounds using VSEPR theory.

   ⟶ **F14** *Chemical Bonding* "VSEPR Theory"

   ⟶ **F15** *Chemical Bonding* "Comparing Shapes"

10. Determine the polarity of a molecular compound by examining its bond dipoles and shape.

    ⟶ **F14** *Chemical Bonding* "Dipole Moments"

11. Apply Lewis structures and formal charge analysis to determine if a compound or polyatomic ion forms resonance structures.

→ **F10** *Chemical Bonding* "Polyatomic Ions"

13. Illustrate how sigma and pi bonds form between atoms in a molecular compound.

→ **S9** *Organic Chemistry* "Isomers of Alkenes and Alkynes"

14. Draw the basic functional groups found in organic molecules.

→ **S15** *Organic Chemistry* "Functional Groups"

15. Draw the structural formulas of simple organic molecules.

→ **S2** *Organic Chemistry* "Straight-Chain Alkanes"
→ **S3** *Organic Chemistry* "Cyclic Hydrocarbons"
→ **S5** *Organic Chemistry* "Isomers of the Alkanes"

Standard 2
States of Matter

Conceptual Strand 2
Kinetic-molecular theory and intermolecular forces are the basis for solid, liquid, gas, and solution phenomena.

Guiding Question 2
How does the interaction between ions and molecules determine the physical state and characteristics of matter?

Course Level Expectations

1. Explain the kinetic-molecular theory.

→ **G6** *Gases* "Gas Pressure"

2. Determine the intermolecular forces that exist between ions and molecules.

→ **H11** *Liquids & Solids* "Intermolecular Forces"

3. Explain how the physical characteristics of matter are governed by kinetic molecular theory and intermolecular forces.

→ **H9** *Liquids & Solids* "Molecular Motion and Physical States"
→ **H11** *Liquids & Solids* "Intermolecular Forces"

Checks for Understanding

1. Correlate the kinetic-molecular theory with the motion of particles within a substance.

→ **H11** *Liquids & Solids* "Intermolecular Forces"

2. Explain the effect of heat on temperature in terms of the motion of the particles within the substance.

→ **G10** *Gases* "The Meaning of Temperature"

→ **G12** *Gases* "Mean Speed and Temperature"

3. Explain how the motion of gas molecules affects the pressure.

→ **G6** *Gases* "Gas Pressure"

4. Explain the effects of temperature changes on the pressure of a gas.

→ **G16** *Gases* "Pressure and Temperature"

5. Explain the effects of pressure changes on the volume of a gas.

→ **G13** *Gases* "Pressure-Volume Relationship"

→ **G14** *Gases* "Boyle's Law"

7. Determine the rates of effusion of gas molecules using Graham's Law of Effusion.

→ **G29** *Gases* "Effusion"

9. Determine the types of intermolecular interactions that occur in a pure substance or between the components of a mixture.

→ **H11** *Liquids & Solids* "Intermolecular Forces"

10. Compare the strengths of intermolecular forces between ions, molecules, and ion-molecule mixtures.

→ **H12** *Liquids & Solids* "Dipole-Dipole Forces"

11. Correlate the strength of intermolecular force with the viscosity, surface tension and physical state of the substance at a given temperature.

→ **H11** *Liquids & Solids* "Intermolecular Forces"

12. Explain the role of intermolecular forces in determining the vapor pressure, volatility and boiling point of a substance.

→ **H11** *Liquids & Solids* "Intermolecular Forces"

→ **H22** *Liquids & Solids* "Vapor Pressure"

→ **H23** *Liquids & Solids* "Liquid-Vapor Equilibrium"

Standard 3

Reactions

Conceptual Strand 3
Chemical reactions can be investigated and described through their stoichiometric, kinetic, equilibrium, and thermodynamic characteristics.

Guiding Question 3
How can the stoichiometric, kinetic, equilibrium, and thermodynamic characteristics of a chemical reaction lead to a further understanding of reaction process?

Course Level Expectations

3. Analyze the kinetics of a chemical reaction.

→ **M1** *Kinetics* "Observing a Reaction"

→ **M2** *Kinetics* "Reactive Collisions"

→ **M3** *Kinetics* "Mechanism of a Reaction"

4. Describe parameters of chemical equilibria.

→ **N2** *Equilibria* "Equilibrium and Temperature"

→ **N3** *Equilibria* "Equilibrium and Pressure"

5. Explain the thermodynamics of a chemical reaction.

→ **M2** *Kinetics* "Reactive Collisions"

Checks for Understanding

2. Use a solubility chart to predict products and write net ionic reactions that identify spectator ions in a double-replacement reaction.

→ **I17** *Solutions* "Miscible and Nonmiscible Liquids"

12. Draw energy profiles for catalyzed and uncatalyzed chemical reactions in terms of activation energy.

→ **M3** *Kinetics* "Mechanism of a Reaction"

13. Write an equilibrium expression and calculate the equilibrium constant based on the concentration of reactants and products at equilibrium.

→ **N2** *Equilibria* "Equilibrium and Temperature"

→ **N3** *Equilibria* "Equilibrium and Pressure"

14. Interpret the magnitude of the equilibrium constant to determine equilibrium concentrations and direction of a chemical reaction that has yet to reach equilibrium.

→ **N2** *Equilibria* "Equilibrium and Temperature"

→ **N3** *Equilibria* "Equilibrium and Pressure"

15. Apply Le Chatelier's Principle to predict shifts in the direction of a chemical reaction in response to changes in temperature, pressure and concentration of reactants or products.

⟶ **N2** *Equilibria* "Equilibrium and Temperature"

⟶ **N3** *Equilibria* "Equilibrium and Pressure"

16. Calculate the percent ionization and pH of a solution given the identity, concentration, and acid/base dissociation constant of an acid or base.

⟶ **K1** *Acids & Bases* "Strong Acids"

19. Characterize the strength of acids and bases by exploring their chemical structures.

⟶ **K2** *Acids & Bases* "Comparing Oxoacids"