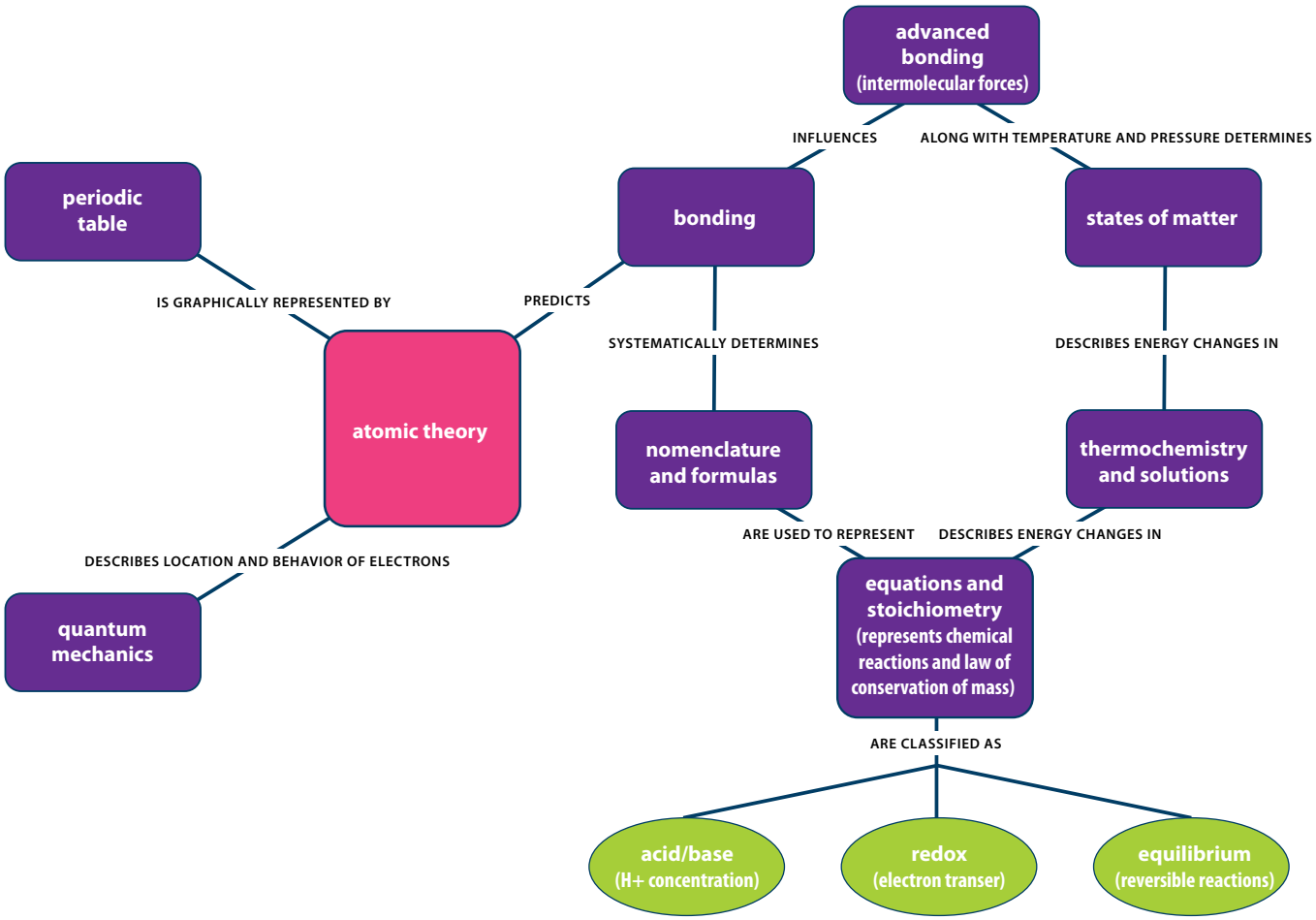
Chemistry Priority Expectations

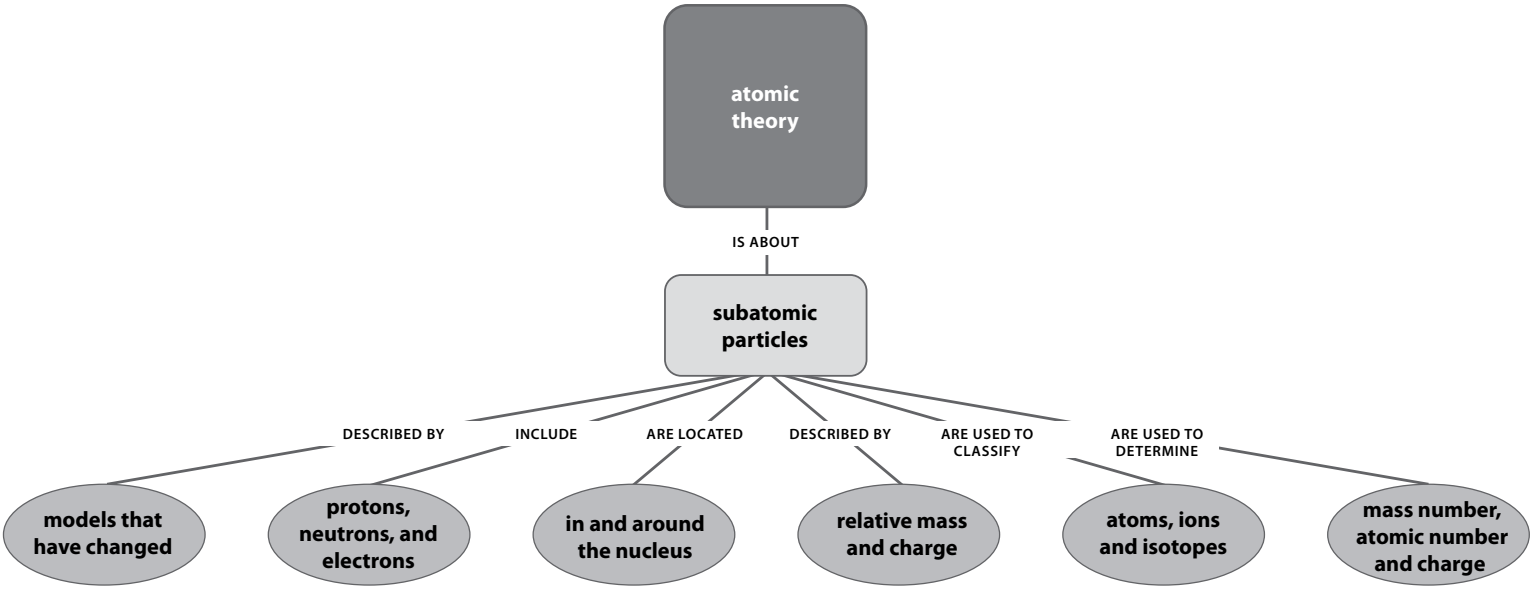


The Big Ideas in the Chemistry Units

Unit 1	**Atomic Theory** Physical, chemical and nuclear changes are explained using the location and properties of subatomic particles.
Unit 2	**Periodic Table** The periodic table organizes all known elements and provides useful information for making predictions in chemistry.
Unit 3	**Quantum Mechanics** Quantum theory provides a foundation for the atomic model and the understanding of electron behavior and arrangement.
Unit 4	**Introduction to Bonding** There are attractions between atoms that increase their stability. *(You may consider teaching unit 4 in conjunction with Unit 8.)*
Unit 5	**Nomenclature and Formula Stoichiometry** Elements form compounds in predictable ratios that can be named systematically.
Unit 6	**Equations and Stoichiometry** Chemical reactions are described by balanced chemical equations which obey the Law of Conservation of Mass.
Unit 7	**States of Matter** States of matter can be explained by attraction between particles under various conditions of temperature and pressure.
Unit 8	**Advanced Bonding Concepts** Many physical properties of substances can be determined by knowing the type of intermolecular forces that exists between particles.
Unit 9	**Thermochemistry and Solutions** The flow of energy, measured by temperature, influences the behavior of matter.
Unit 10	**Acid/base** Hydrogen ion concentration determines pH of the solution which allows its classification as either acidic, basic, or neutral.
Unit 11	**Redox/equilibrium** Electron transfers as described by redox reactions impacts humans in both positive and negative ways. In a closed system, reversible reactions achieve equilibrium which is dependent on pressure, temperature and concentration conditions.
Unit 12	**Thermodynamics** The spontaneity of a reaction is determined by the change in Gibbs Free Energy which is dependent on temperature and the changes in enthalpy and entropy. **(A thorough treatment of Unit 9 is sufficient. No content expectations in unit 12 are priority expectations)*

Unit 1

Atomic Theory



Big Idea

Physical, chemical and nuclear changes are explained using the location and properties of subatomic particles.

Core Concepts

- Atoms are made up of protons, neutrons, and electrons. These particles are defined by charge, mass, and location in the atom.
- Atoms, ions and isotopes are differentiated by their numbers of protons, neutrons and electrons.

Inquiry, Reflection and Social Implications

Note: Teachers may want to use observations of physical and chemical changes through demonstrations or labs to help students understand the necessity to study atomic structure (i.e., macroscopic to microscopic).

C1.2i Explain progression of ideas
Students can explore the changing models of the atom to gain a better understanding of the development of the current model and the dynamic nature of science.

C1.2 D Use peer review to evaluate explanations
Students may construct a model or visual representation of an unknown object (within a black box) based upon their data and present/defend their findings to their peers.

C1.1E Give evidence to support conclusions
Students can investigate an unknown substance.

Unit 1

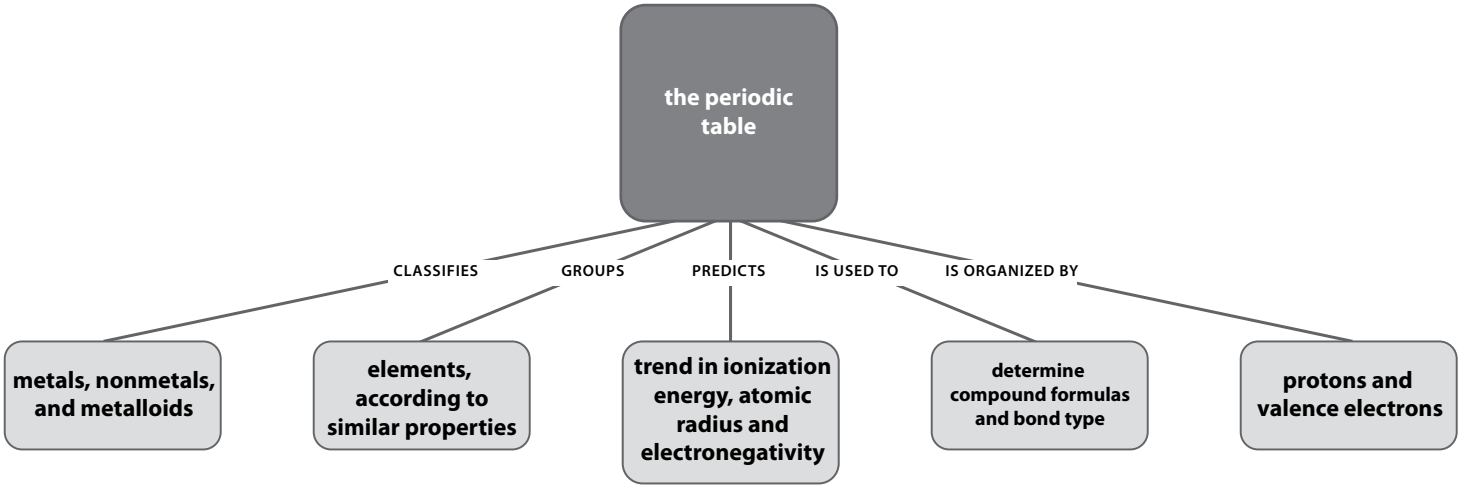
Content Expectations *(Priority Expectations are highlighted in gray.)*

NOTE: C2.5a, C3.5a and C4.7b are considered to be engaging topics that set the stage for the unit topic of Atomic Theory.

C2.5a	Determine the age of materials using the ratio of stable and unstable isotopes of a particular type.
C3.5a	Explain why matter is not conserved in nuclear reactions.
C4.7b	Compare the density of pure water to that of a sugar solution.
C4.8A	**Identify the location, relative mass, and charge for electrons, protons, and neutrons.**
C4.8B	**Describe the atom as mostly empty space with an extremely small, dense nucleus consisting of the protons and neutrons and an electron cloud surrounding the nucleus.**
C4.8C	**Recognize that protons repel each other and that a strong force needs to be present to keep the nucleus intact.**
C4.8D	Give the number of electrons and protons present if the fluoride ion has a -1 charge.
C4.10A	**List the number of protons, neutrons, and electrons for any given ion or isotope.**
C4.10B	**Recognize that an element always contains the same number of protons.**
C4.10e	**Write the symbol for an isotope, XA_Z, where Z is the atomic number, A is the mass number, and X is the symbol for the element.**
C5.2C	Draw pictures to distinguish the relationships between atoms in physical and chemical changes.

Unit 2

Periodic Table



Big Idea

The periodic table organizes all known elements and provides useful information for making predictions in chemistry.

Core Concepts

- In the periodic table, elements are arranged in order of increasing number of protons.
- Vertical groups in the periodic table have similar physical and chemical properties due to the same outer electron configurations (valence electrons).
- By understanding valence electrons, the periodic table can be used to predict chemical bonding.

Inquiry, Reflection and Social Implications

C1.2i Explain progressions of ideas
Students may explore the historical development and changes in the periodic table.

C1.1D Relate patterns in data to theories
Students can observe and graph trends in the periodic table that can be used to make predictions in chemistry.

C1.1 g Critique reasoning based upon evidence
Using a model, students can determine mass and percent abundance of isotopes to determine the average atomic mass.

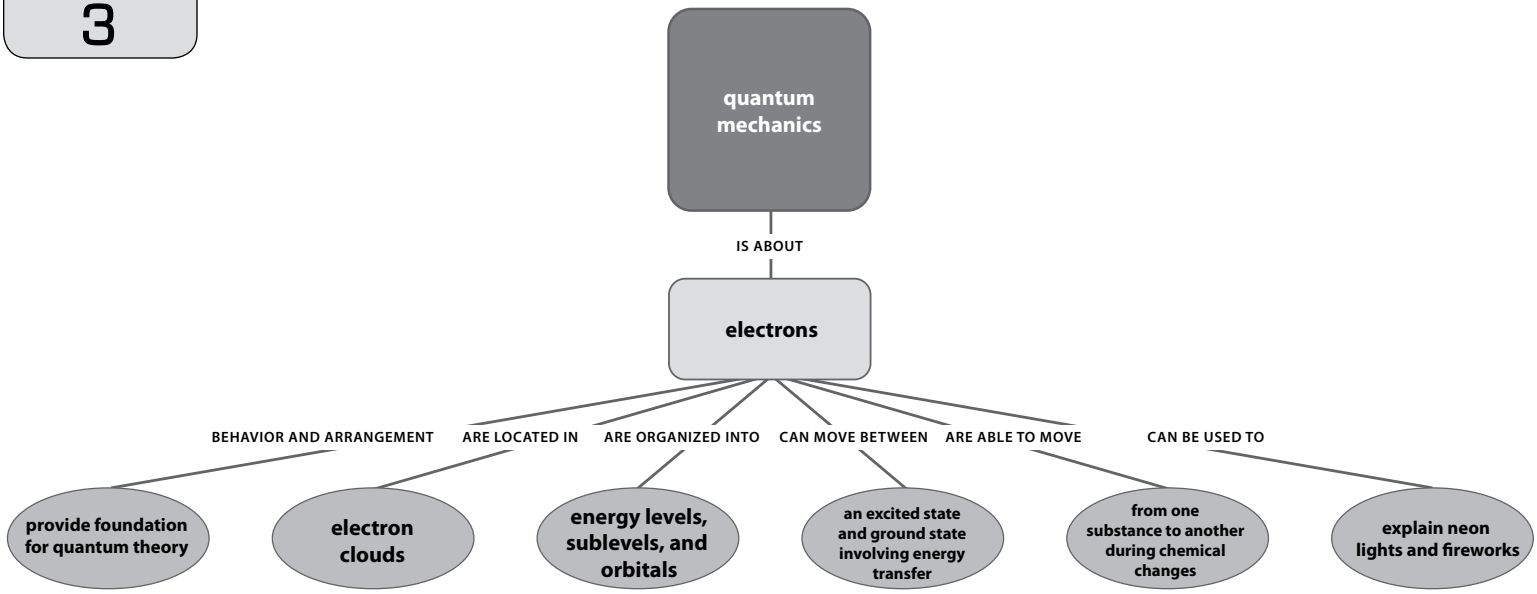
Unit 2

Content Expectations *(Priority Expectations are highlighted in gray.)*

C4.9A	**Identify elements with similar chemical and physical properties using the periodic table.**
C4.9b	**Identify metals, non-metals, and metalloids using the periodic table.**
C4.9c	**Predict general trends in atomic radius, first ionization energy, and electronegativity of the elements using the periodic table.**
C4.10c	Calculate the average atomic mass of an element given the percent abundance and mass of the individual isotopes.
C4.10d	Predict which isotope will have the greatest abundance given the possible isotopes for an element and the average atomic mass in the periodic table.
C5.2g	Calculate the number of atoms present in a given mass of element.
C5.5A	**Predict if the bonding between two atoms of different elements will be primarily ionic or covalent.**
C5.5B	**Predict the formula for binary compounds of main group elements.**
C5.5c	**Draw Lewis structures for simple compounds.**
C5.5d	Compare the relative melting point, electrical and thermal conductivity, and hardness for ionic, metallic, and covalent compounds.

Unit 3

Quantum Mechanics



Big Idea

Quantum theory provides a foundation for the atomic model and the understanding of electron behavior and arrangement.

Core Concepts

- Electrons are arranged in main energy levels with sublevels that specify particular shapes and geometry.
- Evidence for the movement of electrons between different energy levels can be observed through absorption and emission spectra.

Inquiry, Reflection and Social Implications

C1.2i Explain progressions of ideas
Students may explain the evolution of atomic theory. For example students can compare atomic models prior to Rutherford with the Bohr model and electron cloud.

C1.1E Give evidence to support conclusions
Students can use flame test or emission spectra evidence to relate emissions to quantum theory.

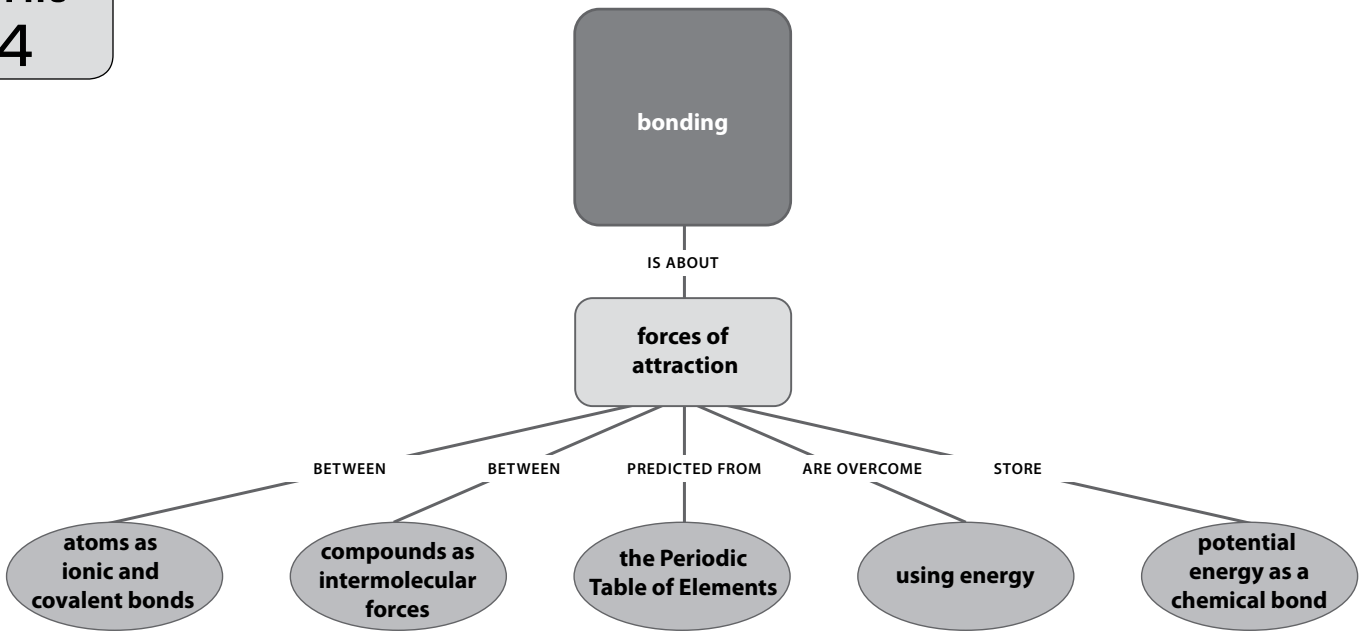
C1.1i Distinguish between consensus and on-going research
Students may examine new research in the field of quantum theory.

Content Expectations *(Priority Expectations are highlighted in gray.)*

C2.4a	Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions.
C2.4b	Contrast the mechanism of energy changes and the appearance of absorption and emission spectra.
C2.4c	**Explain why an atom can absorb only certain wavelengths of light.**
C2.4d	**Compare various wavelengths of light (visible and non-visible) in terms of frequency and relative energy.**
C4.8e	**Write the complete electron configuration of elements in the first four rows of the periodic table.**
C4.8f	Write kernel structures for main group elements.
C4.8g	**Predict oxidation states and bonding capacity for main group elements using their electron structure.**
C4.8h	Describe the shape and orientation of s and p orbitals.
C4.8i	Describe the fact that the electron location cannot be exactly determined at any given time.

Unit 4

Introduction to Bonding*



Big Idea

There are attractions between atoms that increase their stability. ***(You may consider teaching Unit 4 in conjunction with Unit 8)***

Core Concepts

- A chemical bond is the electrostatic attraction between two or more atoms. Chemical potential energy is stored in chemical bonds.
- Chemical reactions involve breaking bonds in reactants (endothermic) and forming new bonds in the products (exothermic).
- The forces of attraction that occur between molecules (called intermolecular forces) are influenced by molecular polarity. Molecular polarity is dependent on bond polarity (polar or nonpolar) and the shape of the molecule.

Inquiry, Reflection and Social Implications

C1.1A Generate questions for investigations

C1.2 A Determine scientifically answerable questions

Students may observe a chemical reaction, generate questions that can be investigated and critique those questions to determine if they can be investigated.

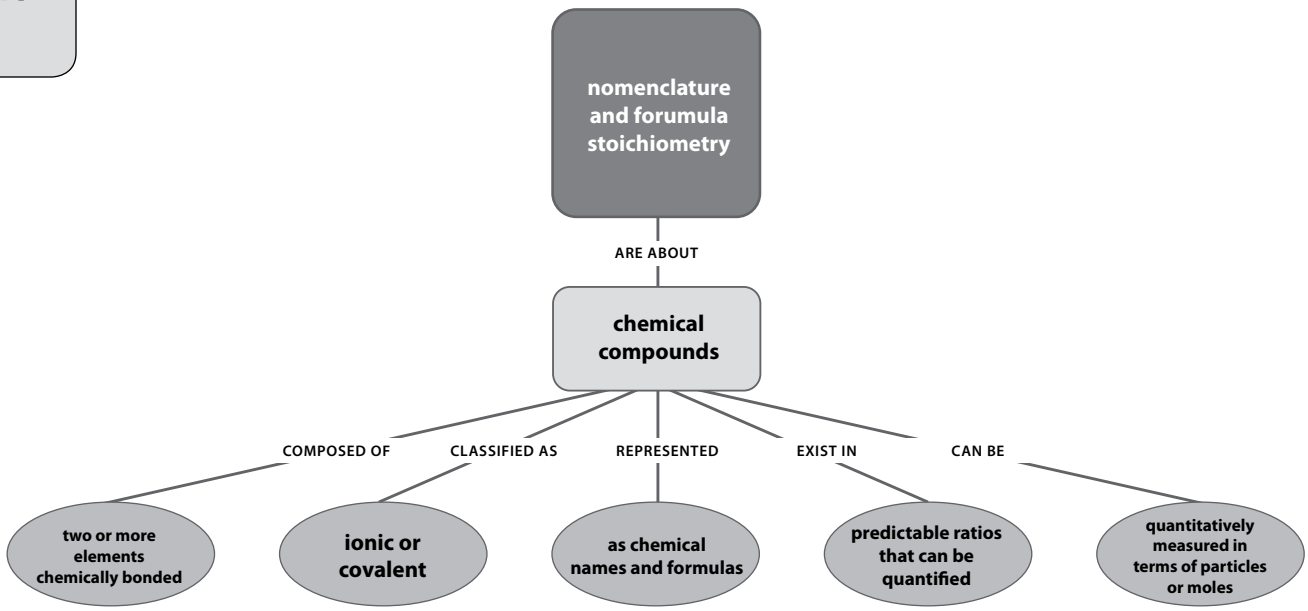
Unit 4

Content Expectations *(Priority Expectations are highlighted in gray.)*

C2.1a	**Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.**
C2.1b	**Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).**
C3.2b	**Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms.**
C3.3c	**Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond.**
C4.4a	**Explain why at room temperature different compounds can exist in different phases.**
C4.4b	**Identify if a molecule is polar or non-polar given a structural formula for the compound.**
C5.8A	Draw structural formulas for up to ten carbon chains of simple hydrocarbons.
C5.8B	Draw isomers for simple hydrocarbons.
C5.8C	Recognize that proteins, starches, and other large biological molecules are polymers.

Unit 5

Nomenclature & Formula Stoichiometry



Big Idea

Elements form compounds in predictable ratios that can be named systematically.

Core Concepts

- All molecular and ionic compounds have unique names and formulas that are determined systematically.
- The mole is the standard unit for counting atomic and molecular particles. Molar mass and Avogadro's number are used when converting masses of compounds or elements into either moles or representative particles.

Inquiry, Reflection and Social Implications

C1.1D Relate patterns in data to theories
Students can determine the chemical formulas and names of ionic compounds.

C1.1B Evaluate conclusions (sources of error)
Students may determine the percent composition of a substance and calculate percent error.

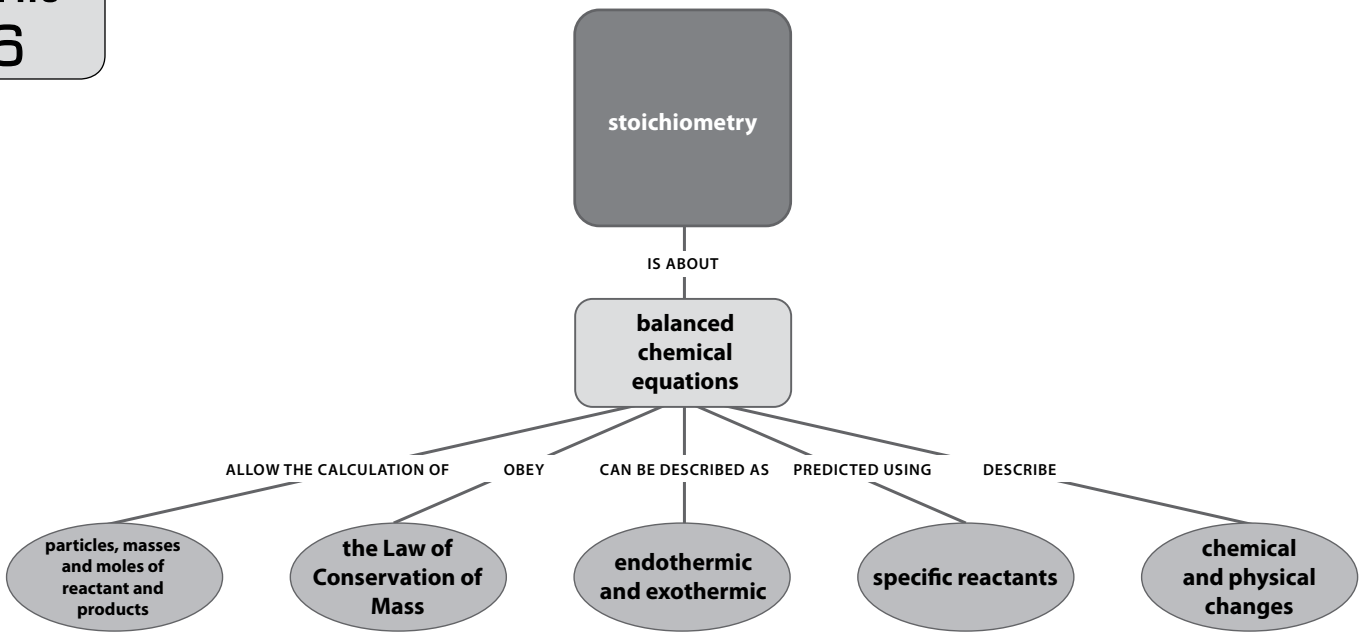
Unit 5

Content Expectations *(Priority Expectations are highlighted in gray.)*

C4.1a	**Calculate the percent by weight of each element in a compound based on the compound formula.**
C4.1b	Calculate the empirical formula of a compound based on the percent by weight of each element in the compound.
C4.1c	Use the empirical formula and molecular weight of a compound to determine the molecular formula.
C4.2A	**Name simple binary compounds using their formulae.**
C4.2B	**Given the name, write the formula of simple binary compounds.**
C4.2c	**Given a formula, name the compound.**
C4.2d	**Given the name, write the formula of ionic and molecular compounds.**
C4.2e	Given the formula for a simple hydrocarbon, draw and name the isomers.
C4.6a	**Calculate the number of moles of any compound or element given the mass of the substance.**
C4.6b	**Calculate the number of particles of any compound or element given the mass of the substance.**

Unit 6

Equations & Stoichiometry



Big Idea

Chemical reactions are described by balanced chemical equations which obey the Law of Conservation of Mass.

Core Concepts

- Chemical changes result in the formation of new substances and can be classified based upon the molecular and submolecular changes that occur.
- During chemical changes, the number of atoms in the reactants is the same as the number of atoms in the products.
- A balanced chemical equation enables the calculation of reaction quantities.

Inquiry, Reflection and Social Implications

C1.2g Identify tradeoffs in design decisions
C1.2j Predict effects of technology
Students may examine how stoichiometry is used in industry.

C1.1E Give evidence to support conclusions
Students should predict the products of chemical reactions.

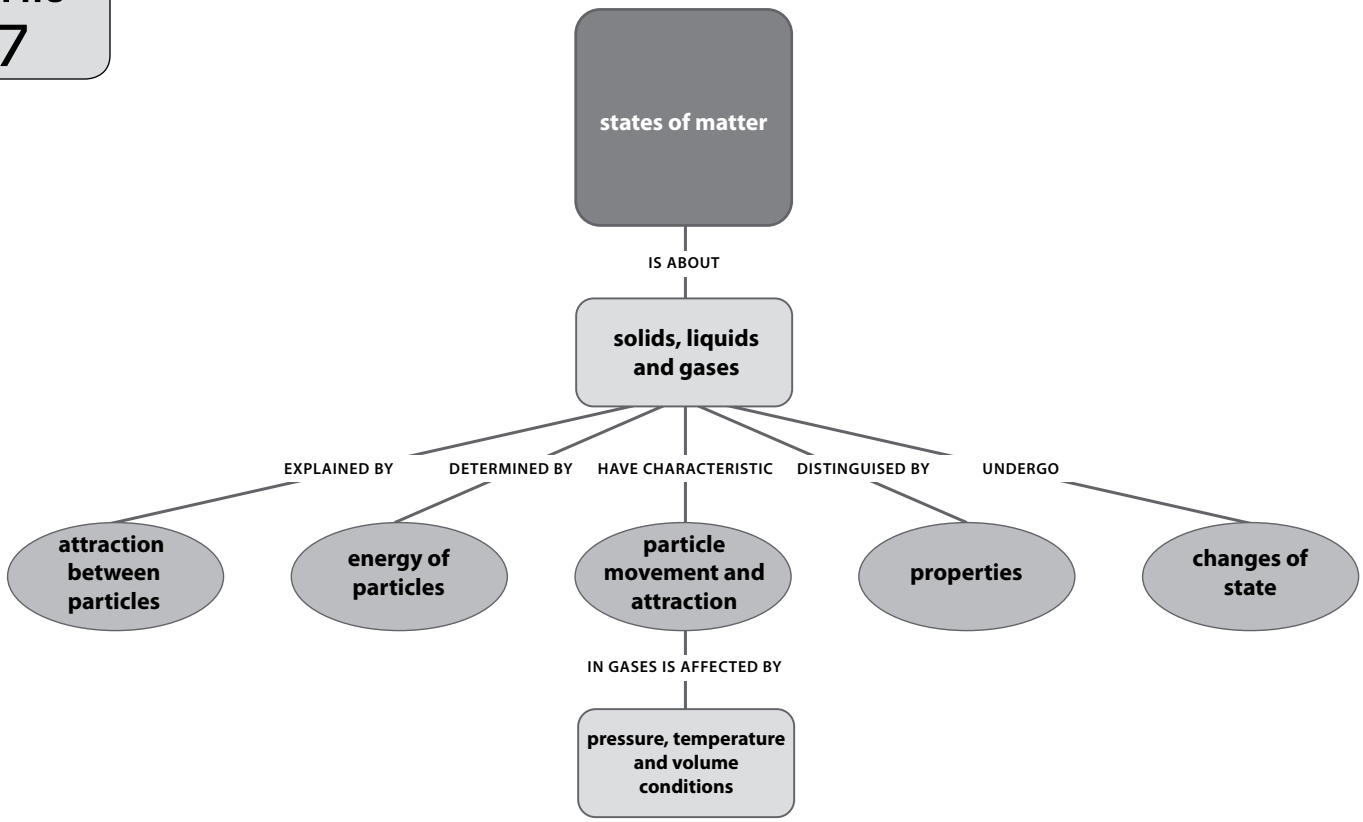
Unit 6

Content Expectations *(Priority Expectations are highlighted in gray.)*

C3.4A	**Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.**
C3.4c	Write chemical equations including the heat term as a part of equation or using ΔH notation.
C5.2A	**Balance simple chemical equations applying the conservation of matter.**
C5.2B	**Distinguish between chemical and physical changes in terms of the properties of the reactants and products.**
C5.2d	**Calculate the mass of a particular compound formed from the masses of starting materials.**
C5.2e	Identify the limiting reagent when given the masses of more than one reactant.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.
C5.6b	**Predict single replacement reactions.**

Unit 7

States of Matter



Big Idea

States of matter can be explained by attraction between particles under various conditions of temperature and pressure.

Core Concepts

- The atoms, molecules and ions that compose matter are in constant motion (kinetic energy). As the average kinetic energy of a substance increases, the temperature also increases.
- The properties of solids, liquids, and gases can be explained by the attractions that occur between particles, as affected by kinetic energy.
- Particle movement and attraction in gases is affected by pressure, temperature and volume conditions.

Inquiry, Reflection and Social Implications

C1.1f Predict results of changes in variables
Students should observe the relationships between pressure, volume, and temperature of gases

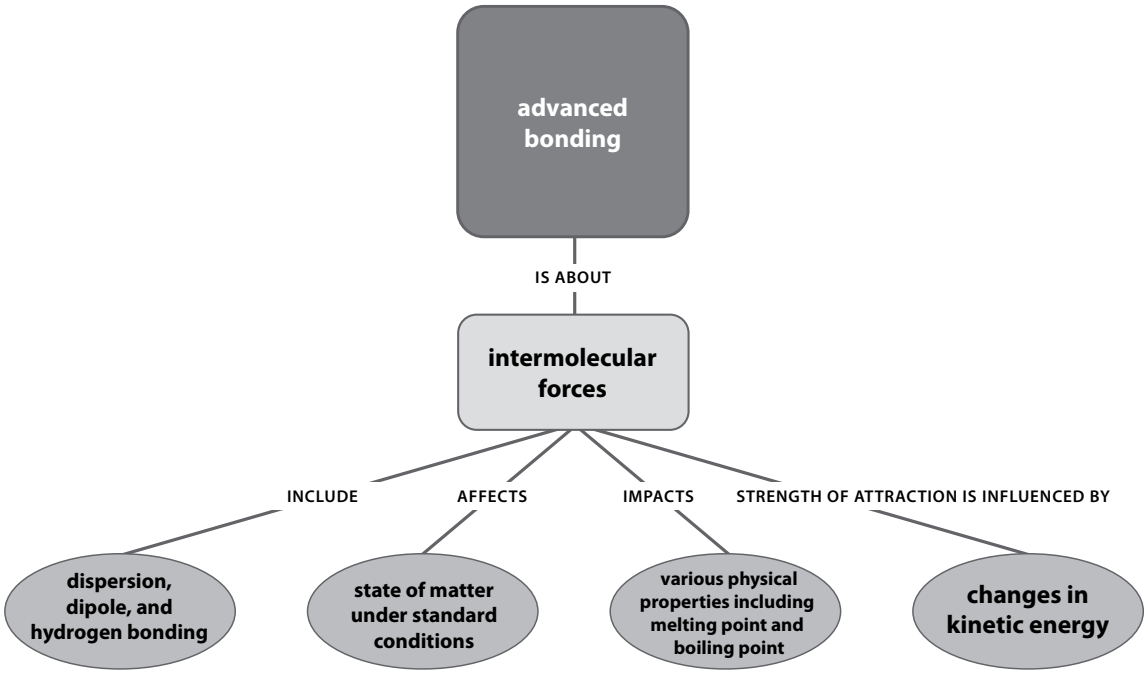
Unit 7

Content Expectations *(Priority Expectations are highlighted in gray.)*

C2.2A	Describe conduction in terms of molecules bumping into each other to transfer energy. Explain why there is better conduction in solids and liquids than gases.
C2.2B	**Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.**
C2.2c:	**Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.**
C2.2f	Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.
C3.3A	Describe how heat is conducted in a solid.
C3.3B	Describe melting on a molecular level.
C4.3A	**Recognize that substances that are solid at room temperature have stronger attractive forces than liquids at room temperature, which have stronger attractive forces than gases at room temperature.**
C4.3B	**Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.**
C4.5a	**Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.**
C4.5b	**Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.**
C4.5c	**Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.**

Unit 8

Advanced Bonding Concepts



Big Idea

Many physical properties of substances can be determined by knowing the type of intermolecular forces that exists between particles.

Core Concepts

- Solids are classified as metallic, ionic, covalent or network covalent based on the forces of attraction that occur between particles.
- For changes of state to occur, a sufficient amount of energy is required to break the forces of attraction between particles (intermolecular forces).

Inquiry, Reflection and Social Implications

C1.1C Conduct scientific investigations
Students can perform various types of chromatography and explain results using solubility.

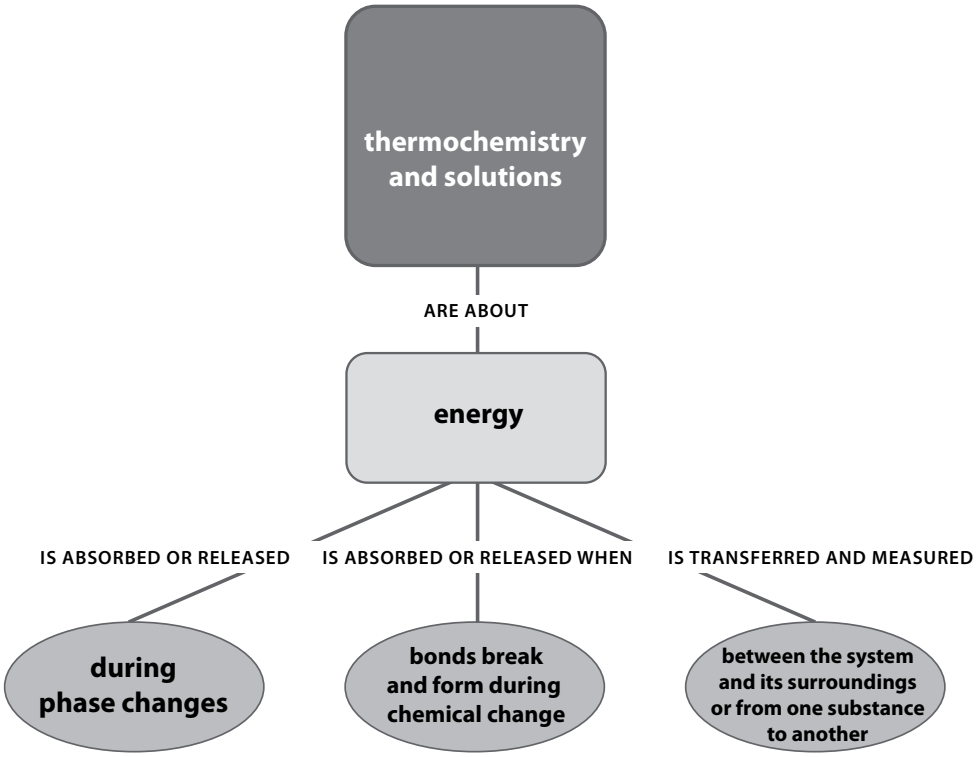
C1.1A Generate questions for investigations
Students can observe the surface tension of different materials and generate questions for differences.

Content Expectations *(Priority Expectations are highlighted in gray.)*

C4.3c	**Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances.**
C4.3d	**Compare the strength of the forces of attraction between molecules of different elements (e.g., at room temperature, chlorine is a gas and iodine is a solid).**
C4.3e	Predict whether the forces of attraction in a solid are primarily metallic, covalent, network covalent, or ionic based upon the elements' location on the periodic table.
C4.3f	**Identify the elements necessary for hydrogen bonding (N, O, F).**
C4.3g	**Given the structural formula of a compound, indicate all the intermolecular forces present (dispersion, dipolar, hydrogen bonding).**
C4.3h	Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.
C4.3i	Explain why ionic solids have higher melting points than covalent solids (e.g., NaF has a melting point of 995°C while water has a melting point of 0° C).
C5.4c	**Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g., ammonia and methane).**
C5.4d	**Explain why freezing is an exothermic change of state.**
C5.4e	**Compare the melting point of covalent compounds based on the strength of IMFs (intermolecular forces).**

Unit 9

Thermochemistry & Solutions



Big Idea

The flow of energy, measured by temperature, influences the behavior of matter.

Core Concepts

- All chemical and physical changes involve energy transfer.
- The amount of heat transferred in a chemical/physical change can be predicted (calculated) using a balanced chemical equation. It can also be measured quantitatively through experimental means and graphically represented.

Inquiry, Reflection and Social Implications

C1.2f Critique solutions to problems
Students may examine the thermochemistry of commercially available products

C1.1C Conduct scientific investigations
C1.1B Evaluate conclusions (measurement error)
Students may perform coffee cup calorimetry

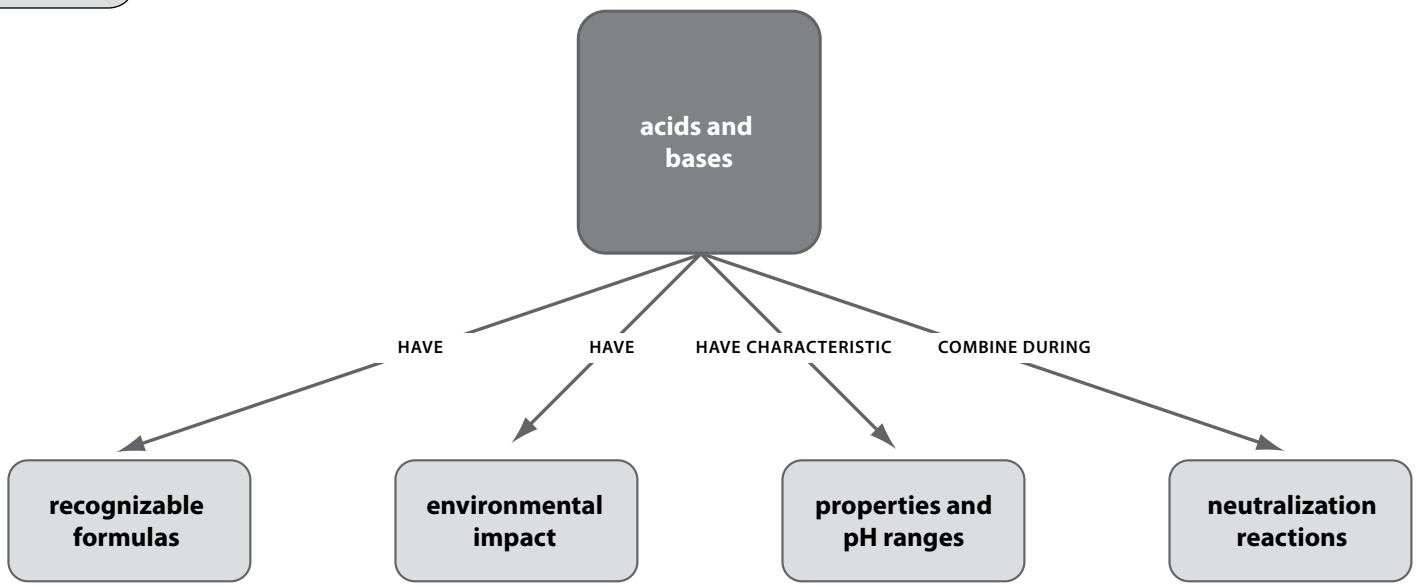
Unit 9

Content Expectations *(Priority Expectations are highlighted in gray.)*

C2.1c	Compare qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid.
C2.2d	Explain convection and the difference in transfer of thermal energy for solids, liquids, and gases using evidence that molecules are in constant motion.
C3.1c	Calculate the ΔH for a chemical reaction using simple coffee cup calorimeter.
C3.1d	**Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.**
C3.4g	Explain why gases are less soluble in warm water than cold water.
C4.7a	Investigate the difference in the boiling point or freezing point of pure water and a salt solution.
C5.4A	**Compare the energy required to raise the temperature of one gram of aluminum and one gram of water the same number of degrees.**
C5.4B	**Measure, plot, and interpret the graph of the temperature versus time of an ice-water mixture, under slow heating, through melting and boiling.**
C5.5e	Relate the melting point, hardness, and electrical and thermal conductivity of a substance to its structure.

Unit 10

Acid/Base



Big Idea

Hydrogen ion concentration determines pH of the solution which allows its classification as either acidic, basic, or neutral.

Core Concepts

- Acids and bases are important classes of chemicals that affect the hydrogen ion concentration in a solution.
- The amount of the hydrogen ion concentration in a solution is the measure of pH. Determining the pH of a solution can be used to distinguish the solution as acidic, basic or neutral.

Inquiry, Reflection and Social Implications

C1.2A Determine scientifically answerable questions
Students may observe changes in pH of substances

C1.2f Critique solutions to problems
Students can examine solutions to the acid rain problem on the environment

C1.2k Analyze how science and society interact
Students discuss the application of neon lights, fireworks, etc. in terms of atomic theory (quantum)

C1.2B Apply science to social issues
C1.2k Analyze how science and society interact
Students could analyze acid rain data and its effect on the environment

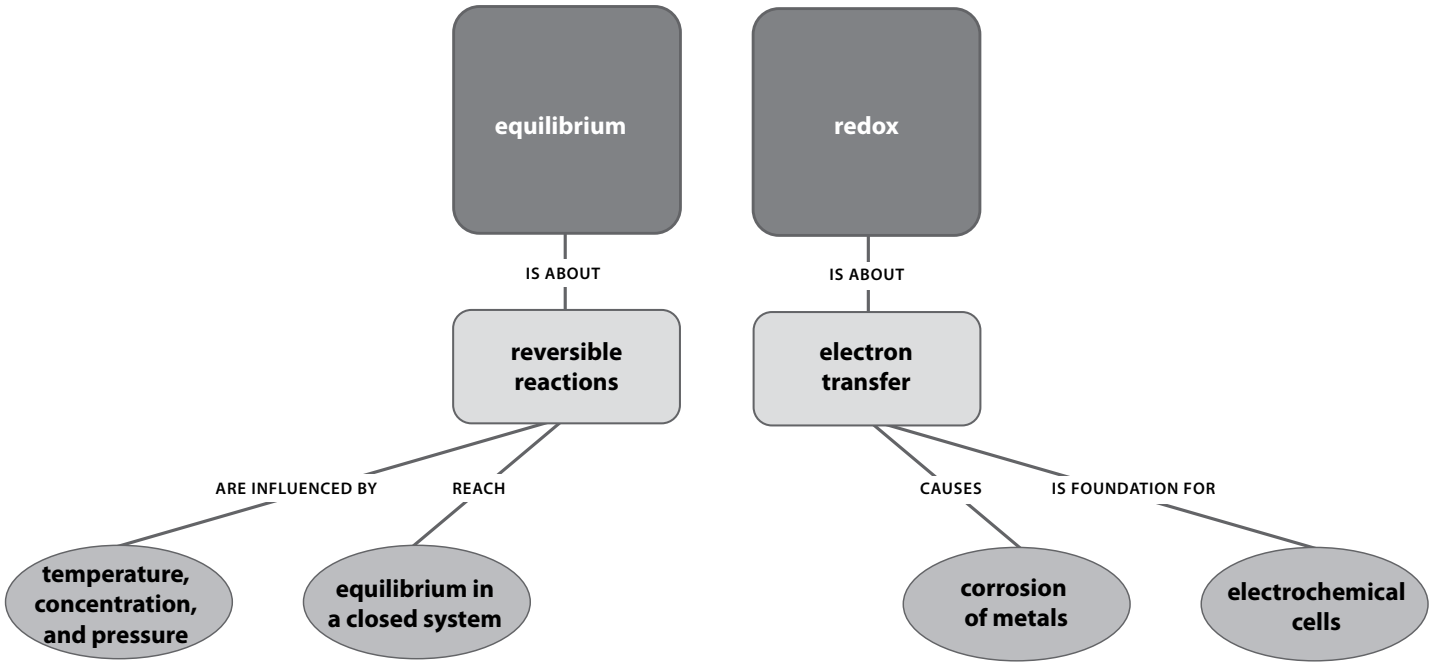
Unit 10

Content Expectations *(Priority Expectations are highlighted in gray.)*

C5.7A	**Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.**
C5.7B	**Predict products of an acid-based neutralization.**
C5.7C	**Describe tests that can be used to distinguish an acid from a base.**
C5.7D	**Classify various solutions as acidic or basic, given their pH.**
C5.7E	Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.
C5.7f	Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations.
C5.7g	Calculate the pH from the hydronium ion or hydroxide ion concentration.
C5.7h	**Explain why sulfur oxides and nitrogen oxides contribute to acid rain.**

Unit 11

Redox/Equilibrium



Big Idea

Electron transfers as described by redox reactions impacts humans in both positive and negative ways.

In a closed system, reversible reactions achieve equilibrium which is dependent on pressure, temperature and concentration conditions.

Core Concepts

- Most chemical reactions reach a state of dynamic equilibrium where the rates of the forward and reverse reactions are equal. This equilibrium, once established, can be altered by changing the conditions of the system.
- Chemical reactions that involve electron transfer are known as oxidation/reduction (redox). The loss of electrons in a reaction is termed oxidation. Reduction is defined as gaining of electrons.

Inquiry, Reflection and Social Implications

C1.2g Identify tradeoffs in design decisions
C1.2j Predict effects of technology
Students can explore the use of redox reactions in society

C1.2k Analyze how science and society interact
Students may discuss the application of the breathalyzer on society

C1.2E Be aware of careers in science
Students can discuss the importance of material science and corrosion technology in future careers

C1.1f Predict results of changes in variables
Students may describe the shift in equilibrium as different variable change.

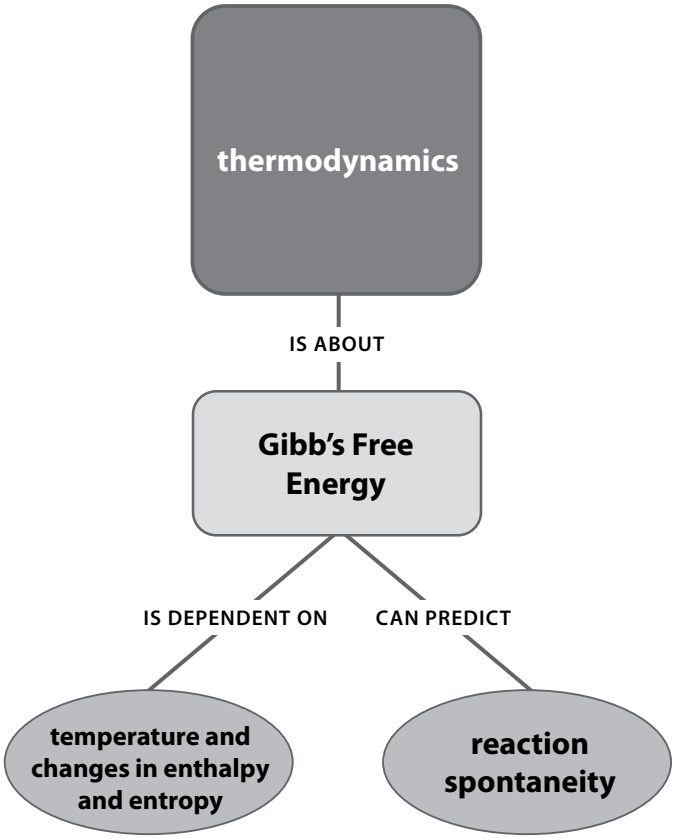
Unit 11

Content Expectations *(Priority Expectations are highlighted in gray.)*

C5.3a	**Describe equilibrium shifts in a chemical system caused by changing conditions (Le Châtelier's Principle).**
C5.3b	**Predict shifts in a chemical system caused by changing conditions (Le Châtelier's Principle).**
C5.3c	Predict the extent reactants are converted to products using the value of the equilibrium constant.
C5.6a	Balance half-reactions and describe them as oxidations or reductions.
C5.6c	**Explain oxidation occurring when two different metals are in contact.**
C5.6d	Calculate the voltage for spontaneous redox reactions from the standard reduction potentials.
C5.6e	**Identify the reactions occurring at the anode and cathode in an electrochemical cell.**

Unit 12

Thermodynamics*



Big Idea

The spontaneity of a reaction is determined by the change in Gibbs Free Energy which is dependent on temperature and the changes in enthalpy and entropy.

(A thorough treatment of Unit 9 is sufficient. No content expectations in Unit 12 are priority expectations)

Core Concept

Inquiry, Reflection and Social Implications

Unit 12

Content Expectations *(Priority Expectations are highlighted in gray.)*

C2.2e	Compare the entropy of solids, liquids, and gases.
C2.3a	Explain how the rate of a given chemical reaction is dependent on the temperature and the activation energy.
C2.3b	Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.
C3.1a	Calculate the ΔH for a given reaction using Hess' Law.
C3.1b	Draw enthalpy diagrams for exothermic and endothermic reactions.
C3.2a	Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.
C3.4B	Explain why chemical reactions will either release or absorb energy.
C3.4d	Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.
C3.4e	Predict if a chemical reaction is spontaneous given the enthalpy (ΔH) and entropy (ΔS) changes for the reaction using Gibb's Free Energy, $\Delta G = \Delta H - T\Delta S$ (Note: mathematical computation of ΔG is not required.)
C3.4f	Explain why some endothermic reactions are spontaneous at room temperature.