

Chemistry

The Chemistry standards are designed to provide students with a detailed understanding of the interaction of matter and energy. This interaction is investigated using experimentation, mathematical reasoning and problem-solving. Areas of study include atomic theory, chemical bonding, chemical reactions, molar relationships, Kinetic Molecular Theory, and thermodynamics. Concepts are illustrated with current practical applications that should include examples from environmental, nuclear, organic, and biochemistry content areas. Technology, including graphing calculators, computers, simulations, and probeware are used when feasible. Students will use chemicals and equipment safely. Mathematics, computational thinking, and experience in the engineering design process are essential as students advance in their scientific thinking.

Scientific and Engineering Practices

Engaging in the practices of science and engineering helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. These scientific and engineering practices include the use of scientific skills and processes to explore the content of science as outlined in the *Science Standards of Learning*. The engineering design practices are an application of the science content while trying to solve a problem or design an object, tool, process, or system. These scientific and engineering practices are critical to science instruction and are to be embedded throughout the year.

CH.1 The student will demonstrate an understanding of scientific and engineering practices by

- a) asking questions and defining problems
 - ask questions that arise from careful observation of phenomena, examination of a model or theory, unexpected results, and/or to seek additional information
 - determine which questions can be investigated within the scope of the school laboratory
 - make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
 - generate hypotheses based on research and scientific principles
 - define design problems that involve the development of a process or system with interacting components, criteria and constraints
- b) planning and carrying out investigations
 - individually and collaboratively plan and conduct observational and experimental investigations
 - plan and conduct investigations or test design solutions in a safe manner, including planning for response to emergency situations
 - select and use appropriate tools and technology to collect, record, analyze, and evaluate data
- c) interpreting, analyzing and evaluating data
 - record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms

- use data in building and revising models, supporting explanations for phenomena, or testing solutions to problems
 - solve problems using mathematical manipulations including the International System of Units (SI), scientific notation, derived units, significant digits, and dimensional analysis
 - analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution
 - analyze data graphically and use graphs to make predictions
 - differentiate between accuracy and precision of measurements
 - consider limitations of data analysis when analyzing and interpreting data
 - analyze data to optimize a design
- d) constructing and critiquing conclusions and explanations
- construct and revise explanations based on valid and reliable evidence obtained from a variety of sources
 - apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions
 - compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence
 - construct arguments or counterarguments based on data and evidence
 - differentiate between scientific hypothesis, theory, and law
- e) developing and using models
- evaluate the merits and limitations of models
 - develop, revise, and/or use models based on evidence to illustrate or predict relationships
 - use models and simulations to visualize and explain the movement of particles, to represent chemical reactions, to formulate mathematical equations, and to interpret data sets
- f) obtaining, evaluating, and communicating information
- compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem
 - gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source
 - communicate scientific and/or technical information about phenomena and/or a design process in multiple formats

Chemistry Content

- CH.2 The student will investigate and understand that elements have properties based on their atomic structure. The periodic table is an organizational tool for elements based on these properties. Key information pertaining to the periodic table includes**
- a) average atomic mass, isotopes, mass number, and atomic number;**
 - b) nuclear decay;**
 - c) trends within groups and periods including atomic radii, electronegativity, shielding effect, and ionization energy;**

- d) electron configurations, valence electrons, excited electrons, and ions; and
- e) historical and quantum models.

Central Idea: The properties of elements, to include the periodic trends, are based on their atomic structure. The periodic table is an organizational tool that allows for the prediction of chemical and physical properties.

Vertical Alignment: Students are introduced to the periodic table as a tool that can be used to predict chemical and physical properties in Physical Science. (Standard PS.2 and PS.4) Students used the periodic tool to identify groups, periods, atomic numbers, atomic masses, and valence electrons.

Enduring Understandings	Essential Knowledge and Practices
<p>Atoms are the basic building blocks of all matter. The properties of an atom are based on the number and arrangement of its parts.</p> <ul style="list-style-type: none"> The subatomic particles have specific characteristics of mass, charge, and location. (CH.2) An isotope is an atom that has the same number of protons as another atom of the same element but has a different number of neutrons. Some isotopes are radioactive. The average atomic mass for each element is the weighted average of that element's naturally occurring isotopes. (a) Nuclear changes involve a change in the composition of the nucleus of an atom and may result in a new element. (b) Half-life is the amount of time it takes for half of the substance to undergo nuclear change and is important in the use and storage of radioactive materials. (b) Electron configuration is a numeric representation of the arrangement of electrons around the nucleus of an atom based on their energy level. The number of paired and unpaired electrons determine chemical properties, particularly bonding. (d) 	<p>In order to meet this standard, it is expected that students will:</p> <ul style="list-style-type: none"> differentiate between a proton, neutron and electron in terms of relative size, composition, charge, and location in the atom. (CH.2) calculate the number of electrons in an ion given its charge. (a) calculate the "weighted" average atomic mass. (a) calculate the number of neutrons in an isotope given its mass number. (a) use equations to predict products of nuclear decay to include those that emit alpha, beta, and gamma radiation. (b) use half-life to determine the amount of a radioactive substance that remains after a designated period of time. (b) use the periodic table as a model to predict relative properties of elements based on the patterns of valence electrons. Relate the position of an element on the periodic table to its electron configuration. (c) compare and contrast elements on the periodic table within a single group or single period in terms of electronegativity, shielding effect, and ionization energy. (c)

Enduring Understandings	Essential Knowledge and Practices
<ul style="list-style-type: none"> Ions form when atoms gain or lose an electron. (d) A valence electron can absorb energy and become excited thus moving to a higher principal energy level. The subsequent of the valence electron to the ground state emits energy that is used in many applications. (d) Electrons occupy equal-energy orbitals so that a maximum number of unpaired electrons results. (d) <p>Predictable patterns of properties emerge when elements are arranged according to the number of valence electrons. Periodic tables model these patterns and can be used to predict properties of elements.</p> <ul style="list-style-type: none"> The periodic table is a tool that shows an organization of elements that allows predictions about physical and chemical properties. The periodic table is arranged in order of increasing atomic numbers. (CH.2, a) Groups (families) have similar properties because of their similar valence electron configurations. (a, d) Periods have predictable properties based on an increasing number of electrons in the outer energy levels. (c) The periodic trends (electronegativity, ionization energy, shielding, and atomic radius) are determined by both the number of principal energy levels of the element and the number of protons of an element. (c) Atomic radius, electronegativity, ionization energy, and shielding are periodic trends that explain chemical properties of elements. (c) 	<ul style="list-style-type: none"> relate the roles of principal energy levels and number of protons to the periodic trends. (c) use electron configurations to predict bonding. (d) identify the number of valence electrons using an element's electron configuration. (d) determine the ions formed when selected atoms gain or lose electrons. (d) explain how excited electrons result in the release of electromagnetic radiation. (d) explain how the development of the modern atomic theory reflects the nature of science. (e)

Enduring Understandings	Essential Knowledge and Practices
<ul style="list-style-type: none"> The periodic table changes as new elements are made in laboratory settings. (CH.2) <p>The Quantum-mechanical model of the atom is a shared understanding that encapsulates our current understanding of the atom. The development of these models illustrates the nature of science. (See LS.2)</p> <ul style="list-style-type: none"> Discoveries and insights related to the atom's structure have changed the model of the atom over time. (e) <i>Students are not responsible for the contributions of specific scientists.</i> 	

CH.3 The student will investigate and understand that atoms are conserved in chemical reactions. Knowledge of chemical properties of the elements can be used to describe and predict chemical interactions. Key ideas include

- chemical formulas are models used to represent the number of each type of atom in a substance;**
- substances are named based on the number of atoms and the type of interactions between atoms;**
- balanced chemical equations model rearrangement of atoms in chemical reactions;**
- atoms bond based on electron interactions;**
- molecular geometry is predictive of physical and chemical properties; and**
- reaction types can be predicted and classified.**

Central Idea: The Law of Conservation of Mass governs all interactions between atoms. These interactions occur as valence electrons are shared and transferred between atoms in the process of bonding. Chemical equations model the interactions of atoms in a chemical reaction and these interactions can be predicted and classified.

Vertical Alignment: Students are introduced to bonding and use simple balanced equations to model chemical reactions in Physical Science. The practice of balancing equations is used to support the Law of Conservation of Mass. (Standard PS.3)

Enduring Understandings	Essential Knowledge and Practices
Matter is conserved because atoms are conserved in chemical and physical processes. The Law of Conservation of Matter (Mass) states that regardless of how substances within	<p>In order to meet this standard, it is expected that students will:</p> <ul style="list-style-type: none"> use particulate models and mathematical representations to support the claim that atoms, and therefore

Enduring Understandings	Essential Knowledge and Practices
<p>a closed system are changed, the total mass remains the same.</p> <ul style="list-style-type: none"> Conservation of matter is represented in balanced chemical equations. A coefficient indicates the relative number of particles involved in the reaction. (CH.3) The products formed in a chemical reaction have different properties than the original reactants. (c) Chemical formulas are used to represent compounds. Subscripts represent the relative number of each type of atom in a molecule or formula unit. (a) <p>Matter consists of atoms held together by electromagnetic forces and exists as different substances which can be utilized based on their properties.</p> <ul style="list-style-type: none"> The strong electrostatic forces of attraction between atoms in a compound are called chemical bonds. (d) Intramolecular bonds form between atoms to achieve stability. Covalent bonds involve the sharing of electrons between nonmetal atoms. Ionic bonds involve the transfer of electrons between metal and nonmetal ions. Elements with low ionization energy form positive ions (cations) easily. Elements with high ionization energy form negative ions (anions) easily. (d) Polar bonds form between covalently bonded elements with very different electronegativities. Non-polar bonds form between covalently bonded elements with similar electronegativities. (d) Some elements, such as hydrogen, oxygen, nitrogen, fluorine, chlorine, bromine, and iodine naturally occur as diatomic molecules. (b) 	<p>mass, are conserved during a chemical reaction. (CH.3)</p> <ul style="list-style-type: none"> name and write the chemical formulas for binary covalent (molecular) and ionic compounds. (b) name and write the chemical formula for ionic compounds containing polyatomic ions. (b) explain how chemical equations support the Law of Conservation of Mass. (c) transform word equations into balanced chemical equations. (b, c) construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of the atom, trends in the periodic table, and knowledge of the periodic properties. (CH.2, c) identify the intramolecular bonds in compounds and predict their physical properties based on the type of bond. (d) conduct an investigation to determine the trends and properties of compounds with ionic and covalent bonds. This investigation may include melting point, solubility, and conductivity. (d) draw Lewis dot diagrams to represent valence electrons in elements and show covalent bonding. (d) compare covalently bonded molecules to determine if the intramolecular bonds are polar or non-polar. (d) explain the molecular shape of a covalently bonded molecule using the valence shell electron pair repulsion (VSEPR) model. (e) describe how the valence electrons of carbon impact its bonding and molecular geometry allowing it to be

Enduring Understandings	Essential Knowledge and Practices
<p>Bonded and non-bonded pairs of electrons can be used to predict molecular geometry.</p> <ul style="list-style-type: none"> Lewis dot diagrams are used to represent valence electrons in an element. Lewis structures can be used to determine the shape of molecules using the VSEPR model (bent, linear, trigonal planar, tetrahedral, and trigonal pyramidal). (e) <p>Carbon is an important element in biological systems and combines with oxygen and hydrogen, as well as other elements to form compounds that are essential for living processes. This class of bonds are called organic compounds.</p> <ul style="list-style-type: none"> Carbon atoms can form single, double, and triple bonds with other carbon atoms. (e) Carbon based compounds have different shapes based on their bonding. (e) The flexibility of carbon to bond in various shapes allows for a wide range of technological application. (e) <p>Classification of chemical equations relies on careful observation of patterns.</p> <ul style="list-style-type: none"> In a chemical process, the atoms that make up the original substance are regrouped into different molecules. (c, f) Many of the products of chemical reactions can be predicted through recognizing patterns. (f) 	<p>important in both biological and technological applications. (e)</p> <ul style="list-style-type: none"> classify chemical reactions as one of the six major types: synthesis, decomposition; single replacement; double replacement; combustion; or neutralization. (f) predict products of single and double replacement reactions given the reactants of the reaction. (f)

CH.4 The student will investigate and understand that molar relationships compare and predict chemical quantities. Key ideas include

- a) Avogadro's principle is the basis for molar relationships; and**
- b) stoichiometry mathematically describes quantities in chemical composition and in chemical reactions.**

Central Idea: In order for chemical equations to be useful, there needs to be a way to measure the quantities of reactants and products. Stoichiometry allows for the quantification of chemical relationships.

Vertical Alignment: Students are introduced to the Law of Conservation of Mass and balanced equations in Physical Science. (Standard PS.3) These topics are covered conceptually and students have no experience prior to chemistry on molar relationships.

Enduring Understandings	Essential Knowledge and Practices
<p>Matter can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change.</p> <ul style="list-style-type: none"> Atoms and molecules are too small to count by usual means. A mole is a fundamental unit for counting particles (atoms, molecules, and formula units). (a) Stoichiometry involves quantitative relationships in a balanced equation which are based on mole ratios. (b) When two elements combine with each other to form two or more compounds, the ratios of the masses of one element that combines with the fixed mass of the other are simple whole numbers (Law of Multiple Proportions). (b) Empirical and molecular formulas are used to show the chemical composition of a compound. Both of these are useful in determining the formula of a substance based on the mass of the elements of an unknown substance. (b) The limiting reactant (reagent) is the reactant that determines the moles of product(s) that can be produced in a reaction. The limiting reactant can be identified through comparing calculated ratio of moles and coefficients of reactants available at the beginning of the reaction. (b) Although matter is conserved, chemical reactions rarely convert all of the reactions to products. Percent yield can be used to determine the efficiency of a reaction as well as the percent error. (b) 	<p>In order to meet this standard, it is expected that students will:</p> <ul style="list-style-type: none"> use particulate models and mathematical representations to model the number of moles in a substance. (a) understand the significance of Avogadro's number and relate Avogadro's number to the mole. (a) convert between mass, volume, and moles of a substance. (a) determine the empirical and molecular formulas of a compound given masses of elements that compose it. (b) conduct an investigation to determine the percent composition and/or the empirical formula of a substance. (b) perform stoichiometric calculations to quantify reactants and/or products in balanced chemical reactions. (b) use particulate models and mathematical representations to identify the limiting reactant in a reaction. (b) conduct an investigation to determine the percent yield of a reaction. (b) plan and conduct an investigation to show how mass or moles are conserved in a chemical reaction. (b) explain how and why limiting reagents affect the production of industrial products. (b)

CH.5 The student will investigate and understand that solutions behave in predictable and quantifiable ways. Key ideas include

- a) molar relationships determine solution concentration;**
- b) changes in temperature can affect solubility;**
- c) extent of dissociation defines types of electrolytes;**
- d) pH and pOH quantify acid and base dissociation; and**
- e) colligative properties depend on the extent of dissociation.**

Central Idea: Solutions are homogeneous mixtures in which the physical properties are dependent on concentration of the solute and the strength of the interactions among the particles of solute and solvent. Molarity is used to quantify the amount of solute in the liters of solution.

Vertical Alignment: Students are introduced to solutions in elementary school and have exposure to acids and bases in Physical Science. (Standard PS.3)The concepts in this standard are novel to most students in Chemistry I.

Enduring Understandings	Essential Knowledge and Practices
<p>Solutions are homogeneous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of solutes and solvents. These forces of attraction are important in determining properties of a substance.</p> <ul style="list-style-type: none">• Temperature impacts the solubility of a solute. A solubility chart indicates the effect of temperature on the solubility of a substance. (c)• Colligative properties are properties dependent on the amount of solute dissolved in a solution. (e)• As solute particle numbers increase, the boiling point of a solution increases and the freezing point decreases. (e) <i>Students are not responsible for calculating boiling point elevation and freezing point depression.</i>• Many substances with ionic bonds dissociate when added to a polar solvent. This dissociation is caused as the different ions of the solute are attracted to the polar solvent. (c)	<p>In order to meet this standard, it is expected that students will:</p> <ul style="list-style-type: none">• calculate the molarity of a solution. (a)• interpret solubility curves to determine the impact of temperature on solution concentration. (b)• apply the terms dilute, saturated and supersaturated to solutions. (c)• explain the phrase “like dissolves like” and use it to predict solubility. (c)• apply the terms strong electrolyte, weak electrolyte, and non-electrolyte to different solutions. (c)• write balanced chemical equations of neutralization reactions between strong acids and strong bases. (d)• explain the difference between strength and concentration of acids and bases. (d)• relate the hydronium ion concentration to the pH scale. (d)• differentiate between the pH and pOH scales and determine acid and base concentrations using each scale. (d)• perform strong acid-strong base titrations using indicators and calculate the

Enduring Understandings	Essential Knowledge and Practices
<ul style="list-style-type: none"> • Polar substances dissolve ionic or polar substances; nonpolar substances dissolve nonpolar substances. (c) <p>Acids and bases are a subset of solutions and react chemically in characteristic ways.</p> <ul style="list-style-type: none"> • Acids and bases form when ionic compounds dissociate producing hydrogen ion (H^+) or hydroxide ion (OH^-). (d) • The pH scale allows for a comparison of the dissociation of an acid or base. (d) • Acids and bases are described through several theories (Arrhenius and Bronsted-Lowry theories). The construction and revising of these theories demonstrate the nature of science. (d) • Titrations are conducted in the laboratory in conjunction with calculations to determine the concentration of an acid or base. (d) • Indicators can be used to determine the pH of a solution. (d) 	<p>concentration of the unknown molarity solution. (d)</p> <ul style="list-style-type: none"> • explain the role of indicators in titrations. (d) • explain how the development of the acid-base theories reflects the nature of science. (d) • explain the role of dissociation of solutes in the boiling point and freezing point of a solution. (e) • describe how colligative properties are used in everyday applications. (e)

CH.6 The student will investigate and understand that the phases of matter are explained by the Kinetic Molecular Theory. Key ideas include

- a) pressure and temperature define the phase of a substance;**
- b) properties of ideal gases are described by gas laws; and**
- c) intermolecular forces affect physical properties.**

Central Idea: The movement of atoms and the relationship of energy and the phases is outlined in the Kinetic Molecular Theory. The gas laws describe the relationships of pressure, volume, temperature and number of particles of a gas.

Vertical Alignment: In Physical Science, students are introduced to the constant movement of atoms and the relationship of the kinetic energy of in a substance and Kelvin temperature through the study of the Kinetic Molecular Theory. The role of energy in phase changes is discussed. (Standard PS.2)

Enduring Understandings	Essential Knowledge and Practices
The Kinetic Molecular Theory (KMT) of gases is a model that helps understand the	In order to meet this standard, it is expected that students will:

Enduring Understandings	Essential Knowledge and Practices
<p>physical properties of gases at the molecular level. (CH.6)</p> <ul style="list-style-type: none"> • Gases have mass and occupy space. Gas particles are in constant, rapid, random motion and exert pressure as they collide with the walls of their containers. Gas molecules with the lightest mass travel fastest. Relatively large distances separate gas particles from each other. (CH.6) • Equal volumes of gases at the same temperature and pressure contain an equal number of particles. (a) • Solid, liquid, and gas phases of a substance have different energy content. Pressure, temperature, and volume changes can cause a change in physical state. Specific amounts of energy are absorbed or released during phase changes. (a) <p>The gaseous state can be modeled through mathematical equations relating macroscopic properties.</p> <ul style="list-style-type: none"> • An ideal gas does not exist, but this concept is used to model gas behavior. A real gas exists, has intermolecular forces and particle volume, and can change states. The Ideal Gas Law states that $PV = nRT$ and includes the relationship between pressure, volume, temperature and the number of moles. (b) • The pressure and volume of a sample of a gas at constant temperature are inversely proportional to each other (Boyle's Law: $P_1V_1 = P_2V_2$). (b) • At constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute temperature (Charles' Law: $V_1/T_1 = V_2/T_2$). (b) 	<ul style="list-style-type: none"> • explain the behavior of gases using the Kinetic Molecular Theory. (CH.6) • explain deviations in the behavior of real gases from the ideal gas law using the Kinetic Molecular Theory. (CH.6, b) • use the Kinetic Molecular Theory to describe the relationships between volume, temperature, pressure, and the number of moles in a sample of gas. (b) • solve problems and interpret graphs including pressure, temperature, volume, and moles of a gas. (b) • plan and conduct an experiment that confirms the effect of a change in pressure, temperature, and/or volume of a gas. (a, b) • create a particulate model that shows the relationship between temperature, pressure, volume and/or the number of moles of a gas. (a, b) • explain how intermolecular forces account for the physical properties of matter. (c) • explain how intermolecular forces differ from intramolecular bonds. (c)

Enduring Understandings	Essential Knowledge and Practices
<ul style="list-style-type: none"> • The Combined Gas Law ($P_1V_1/T_1 = P_2V_2/T_2$) relates pressure, volume, and temperature of a gas. (b) • The sum of the partial pressures of all the components in a gas mixture is equal to the total pressure of a gas mixture (Dalton's law of partial pressures). (b) <p>Intermolecular forces play a key role in determining the properties of a substance.</p> <ul style="list-style-type: none"> • Forces of attraction (intermolecular forces) between molecules determine their state of matter at a given temperature. Forces of attraction include hydrogen bonding, dipole-dipole attraction, and London dispersion (van der Waals) forces. (c) • Intermolecular forces are significantly weaker than intramolecular forces. (c) • Vapor pressure is the pressure of the vapor found directly above a liquid in a closed container. When the vapor pressure equals the atmospheric pressure, a liquid boils. Volatile liquids have high vapor pressures, weak intermolecular forces, and low boiling points. Nonvolatile liquids have low vapor pressures, strong intermolecular forces, and high boiling points. (c) • Energy is required in order to break intermolecular forces to allow a phase change to occur from solid to liquid and from liquid to gas. (c) 	

CH.7 The student will investigate and understand that thermodynamics explains the relationship between matter and energy. Key ideas include

- heat energy affects matter and interactions of matter;**
- heating curves provide information about a substance;**
- reactions are endothermic or exothermic;**
- energy changes in reactions occur as bonds are broken and formed;**
- collision theory predicts the rate of reactions;**
- rates of reactions depend on catalysts and activation energy; and**

g) enthalpy and entropy determine the extent of a reaction.

Central Idea: Thermodynamics is the branch of science that deals with the relationship of heat and other forms of energy. Chemical systems undergo three main processes that use thermal energy: phase changes, heating/cooling, and chemical reactions.

Vertical Alignment: In Physical Science, students were introduced to energy transfer and transformation to include chemical energy. The dissolution and formation of bonds during chemical reactions involves chemical energy and terms such as exothermic and endothermic are used to explain if energy is absorbed or release as a result of a chemical reaction. (Standard PS.5)

Enduring Understandings	Essential Knowledge and Practices
<p>Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions.</p> <ul style="list-style-type: none">• Temperature is a measurement of the average kinetic energy in a sample. There is a direct relationship between temperature and average kinetic energy. (a)• A heating curve graphically describes the relationship between temperature and energy (heat). It can be used to identify a substance's phase of matter at a given temperature as well as the temperature(s) at which it changes phase. It also shows the strength of the intermolecular forces present in a substance. (b)• The energy changes in chemical reactions occurs when atoms rearrange to form new substances. Breaking bonds require energy and making bonds releases energy. (d) <p>Chemical and physical transformations typically involve a change in energy. The relationship between the temperature and the total energy of a system depends on the types, states, and amount of matter.</p> <ul style="list-style-type: none">• All reactions involve the transfer of energy. Enthalpy is a measure of the energy of a chemical or physical system. Since enthalpy cannot be directly measured, the change in enthalpy is used to determine the heat given off or absorbed in a given reaction. (a, g)	<p>In order to meet this standard, it is expected that students will:</p> <ul style="list-style-type: none">• contrast temperature and heat. (a)• explain how energy transfer plays a role in the heating and cooling of a system, in phase transitions, and in chemical reactions. (a, c)• interpret heating curves and reaction diagrams to draw conclusions about energy transfers with a system. (b)• predict the phase of water if pressure or temperature of a substance changes through interpreting a phase diagram of water. (b)• create a particulate model of a phase change. (a)• calculate energy changes, using specific heat capacity. (a)• use calorimetry to measure the amount of thermal energy released or absorbed during a chemical reaction. (a, c)• explain role of energy in bond formation and the breaking of bonds. (d)• create a particulate model that describes necessary particle interactions needed for a chemical reaction to occur (collision theory). (e)

Enduring Understandings	Essential Knowledge and Practices
<ul style="list-style-type: none"> • Endothermic reactions require an input of energy to proceed and are signified by a positive enthalpy. (c, g) • Exothermic reactions release energy upon completion and are signified by a negative enthalpy. (c, g) • The enthalpy (ΔH) of a reaction can be determined through a variety of ways to include calorimetry and calculating bond energies. (c, d, g) <i>Students are not responsible for calculations of bond energy and the use of Hess's Law.</i> • Calorimetry is an experimental technique that is used to determine the thermal energy exchanged/transferred in a chemical system. (a) • Bond energy is the energy required to break a chemical bond. One way the enthalpy of a reaction can be determined is by comparing the bond energies associated with the breaking (endothermic) and forming of bonds (exothermic) in a reaction. (d) <i>Students are not responsible for calculations of bond energy and the use of Hess's Law.</i> • Molar heat of fusion is a property that describes the amount of energy needed to convert one mole of a substance between its solid and liquid states. Molar heat of vaporization is a property that describes the amount of energy needed to convert one mole of a substance between its liquid and gas states. (a) • Specific heat capacity is a property of a substance that tells the amount of energy needed to raise one gram of a substance by one degree Celsius. The values of these properties are related to the strength of their intermolecular forces. (a) <p>The rates of reactions are influenced by the concentration or pressure of the reactants, the</p>	<ul style="list-style-type: none"> • describe the factors that affect the rate of a chemical reaction. (e) • apply scientific principles and evidence to provide an explanation of the effects of changing temperature or concentration of the reacting particles on the rate that a reaction occurs.(e) • explain the role of catalysts in a reaction and describe the effect on a system if a catalyst is not present. (f) • distinguish between enthalpy and entropy. (g) • recognize that there is a natural tendency for systems to increase entropy. (g)

Enduring Understandings	Essential Knowledge and Practices
<p>phase of the reactants or products, and the environmental factors such as temperature.</p> <ul style="list-style-type: none"> • The collision theory is used to predict the rate of chemical reactions. It is based on the assumption that for a reaction to occur it is necessary for the reacting species (atoms or molecules) to come together with the right amount of energy and the geometric orientation needed in order to break existing bonds and to reform new bonds. (e) • Activation energy is the amount of energy needed to start a chemical reaction. (f) • A catalyst is a chemical agent that can lower the activation needed to start a chemical reaction. The catalyst is not consumed or altered in a chemical reaction. (f) • Entropy (S) is a thermodynamic quantity representing the degree of disorderliness or randomness in a chemical system. (g) • <i>Enthalpy (H) is related to the internal energy. When a process occurs at constant pressure, the heat evolved (either released or absorbed) is equal to the change in enthalpy. Exothermic reactions are favored. (g) Students are not responsible for determining enthalpy that occur with changes in pressure.</i> 	

