Chemistry

Topic ***Atomic Structure***

Content Elaborations

The physical science syllabus included properties and locations of protons, neutrons and electrons, atomic number, mass number, cations and anions, isotopes and the strong nuclear force that hold the nucleus together. In this course, the historical development of the atom and the positions of electrons are explored in more detail.

Atomic models are constructed to explain experimental evidence and make predictions. The changes in the atomic model over time exemplify how scientific knowledge changes as new evidence emerges and how technological advancements like electricity extend the boundaries of scientific knowledge. Thompson's study of electrical discharges in cathode-ray tubes led to the discovery of the electron and the development of the plum pudding model of the atom. Rutherford's experiment, in which he bombarded gold foil with **α** -particles, led to the discovery that most of the atom consists of empty space with a relatively small, positively charged nucleus. Bohr used data from atomic spectra to propose a planetary model of the atom in which electrons orbit the nucleus, like planets around the sun. Later, Schrödinger used the idea that electrons travel in waves to develop a model in which electrons travel randomly in regions of space called orbitals (quantum mechanical model).

Based on the quantum mechanical model, it is not possible to predict exactly where electrons are located but there is a region of space surrounding the nucleus in which there is a high probability of finding an electron (electron cloud or orbital). Data from atomic spectra (emission and absorption) gives evidence that electrons can only exist at certain discrete energy levels and not at energies between these levels. Atoms are usually in the ground state where the electrons occupy orbitals with the lowest available energy. However, the atom can become excited when the electrons absorb a photon with the precise amount of energy (indicated by the frequency of the photon) to move to an orbital with higher energy. Any photon without this precise amount of energy will be ignored by the electron. The atom exists in the excited state for a very short amount of time. When an electron drops back down to the lower energy level, it emits a photon that has energy equal to the energy difference between the levels. The amount of energy is indicated by the frequency of the light that is given off and can be measured. Each element has a unique emission and absorption spectrum due to its unique electron configuration and specific electron energy jumps that are possible for that element. Being aware of the quantum mechanical model as the currently accepted model for the atom is important for science literacy as it explains and predicts subatomic interactions, but details should be reserved for more advanced study.

Electron energy levels consist of sublevels (s, p, d and f), each with a characteristic number and shape of orbitals. The shapes of d and f orbitals will not be assessed in high school. Orbital diagrams and electron configurations can be constructed to show the location of the electrons in an atom using established rules. However, the names of these rules will not be assessed. Valence electrons are responsible for most of the chemical properties of elements. In this course, electron configurations (extended and noble gas notation) and orbital diagrams can be shown for any element in the first three periods.

Although the quantum mechanical model of the atom explains the most experimental evidence, other models can still be helpful. Thinking of atoms as indivisible spheres is useful in explaining many physical properties of substances, such as the state (solid, liquid or gas) of a substance at room temperature. Bohr's planetary model is useful to explain and predict periodic trends in the properties of elements.

Note: Quantum numbers and equations of de Broglie, Schrödinger and Plank are beyond the scope of this course.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Trace the historical development of the atomic model including the contributions of Thompson, Rutherford, Bohr and Schrödinger. • Understand the locations of electrons in the atom including electron configurations, orbital diagrams, and the *s, p, d,* and *f* sublevels. • Evaluate the role of electrons in the atomic emission and absorption spectrums and the quantum mechanical models.	• Include the equations of deBroglie and Planck in discussions of the atomic models. • Assign quantum numbers to the electrons in an atom. • Identify the application of Hund's Rule, the Aufbau Principle and the Pauli Exclusion Principle in the locations of electrons. • Exceptions to electron configurations. • Write the electron configuration for any element on the periodic table or any ion.	

Additional Resources

Pacing:

Content Vocabulary (to be assessed)	Academic Vocabulary		
• physical property	• absorption	• emission	• per
• chemical property	• abundance	• emit	• plausible
• atomic spectra	• analogy	• estimate	• predict
• emission	• analyze	• evaluate	• produce
• absorption	• approximate	• evidence	• proportional
• quantum	• balanced	• expand	• propose
• photon	• calculate	• hypothesize	• qualitative
• energy level	• characteristic	• infer	• quantify
• orbital	• classify	• interact	• quantitative
• sublevel	• coefficient	• interpret	• simultaneous
• ground state	• compare	• inversely proportional	• spectrum
• excited state	• continuum		• subscript
• valence electron	• correlate	• magnitude	• transfer
• subatomic	• criteria	• manipulate	• trend
• electron configuration	• directly proportional	• measure	• valid

Chemistry

• orbital diagram • indivisible sphere • state • electron cloud • quantum number*	• distinguish • observe • pattern • yields
Formative Assessments Homework Assignments Labs Quizzes	**Summative Assessments** Unit Tests Lab Practicals
Integrations **ELA:** Aligning to the CCSS ELA Reading and Writing Standards **Math:** Continuous use of algebraic manipulation and practical applications **Social Studies:** Connections to modern society and impact of historical discoveries	**Intervention Strategies*** Science Academic Assistant Review Sheets & Study Guides Extra Practice Worksheets Formative Assessments
Resources Textbook Online Simulations (PhET) Chemthink.com	**Enrichment Strategies** Utilize honors learning targets for regular chemistry and utilize AP Chemistry learning targets for honors chemistry.

Chemistry

Topic	*Periodic Table*

Content Elaborations

In the physical science syllabus, elements are placed in order of increasing atomic number in the periodic table such that elements with similar properties are placed in the same column. How the periodic table is divided into groups, families, periods, metals, nonmetals and metalloids also was in the physical science syllabus. In chemistry, with more information about the electron configuration of elements, similarities in the configuration of the valence electrons for a particular group can be observed. The electron configuration of an atom can be written from the position on the periodic table. The repeating pattern in the electron configurations for elements on the periodic table explain many of the trends in the properties observed. Atomic theory and bonding must be used to explain trends in properties across periods or down columns including atomic radii, ionic radii, first ionization energies, electronegativities and whether the element is a solid or gas at room temperature. Additional ionization energies, electron affinities and periodic properties of the transition elements, lanthanide and actinide series is reserved for more advanced study.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Link the electron configuration of an atom with its location on the periodic table and group/family trends and similarities (atomic radii, ionic radii, first ionization energies, electronegativities).	• Examine additional ionization energies, electron affinities and periodic properties of the transition elements.	

Additional Resources

Pacing

Content Vocabulary (to be assessed)	Academic Vocabulary		
• group	• absorption	• emission	• per
• family	• abundance	• emit	• plausible
• period	• analogy	• estimate	• predict
• metalloid	• analyze	• evaluate	• produce
• periodic	• approximate	• evidence	• proportional
• ionization	• balanced	• expand	• propose
• electronegativity	• calculate	• hypothesize	• qualitative
• electron affinity*	• characteristic	• infer	• quantify
• atomic radii	• classify	• interact	• quantitative
• ionic radii	• coefficient	• interpret	• simultaneous
• ionization energy	• compare	• inversely	• spectrum

Chemistry

• lanthanide* • actinide*	• continuum • correlate • criteria • directly proportional • distinguish proportional • magnitude • manipulate • measure • observe • pattern • subscript • transfer • trend • valid • yields
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Resources Textbook Online Simulations (PhET) Chemthink.com	**Enrichment Strategies** Utilize honors learning targets for regular chemistry and utilize AP Chemistry learning targets for honors chemistry.

Chemistry

Topic ***Intramolecular Chemical Bonding***

Content Elaborations

In the physical science syllabus, atoms with unpaired electrons tend to form ionic and covalent bonds with other atoms forming molecules, ionic lattices or network covalent structures. In this course, electron configurations, electronegativity values and energy considerations will be applied to bonding and the properties of materials with different types of bonding.

Atoms of many elements are more stable as they are bonded to other atoms. In such cases, as atoms bond, energy is released to the surroundings resulting in a system with lower energy. An atom's electron configuration, particularly the valence elections, determines how an atom interacts with other atoms. Molecules, ionic lattices and network covalent structures have different, yet predictable, properties that depend on the identity of the elements and the types of bonds formed.

Differences in electronegativity values can be used to predict where a bond fits on the continuum between ionic and covalent bonds. The polarity of a bond depends on the electronegativity difference and the distance between the atoms (bond length). Polar covalent bonds are introduced as an intermediary between ionic and pure covalent bonds. The concept of metallic bonding also is introduced to explain many of the properties of metals (e.g., conductivity). Since most compounds contain multiple bonds, a substance may contain more than one type of bond. Compounds containing carbon are an important example of bonding, since carbon atoms can bond together and with other atoms, especially hydrogen, oxygen, nitrogen and sulfur, to form chains, rings and branching networks that are present in a variety of compounds, including synthetic polymers, fossil fuels and the large molecules essential to life. Detailed study of the structure of molecules responsible for life is reserved for more advanced courses.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Determine the type of bond between atoms based upon valence electrons and the differences in the electronegativities. • Attribute the physical and chemical properties of compounds to the bond types (ionic, covalent, polar covalent, and metallic). • Extend bond knowledge to include carbon chains.		• Discuss practical applications of bonding in plastics and metals.

Additional Resources

Pacing

Chemistry

Content Vocabulary (to be assessed)	Academic Vocabulary
• unpaired • ionic • covalent • ionic lattice • network covalent • stable • inert • predictable • polarity • conductivity • branching network • synthetic • polymer	• absorption • abundance • analogy • analyze • approximate • balanced • calculate • characteristic • classify • coefficient • compare • continuum • correlate • criteria • directly proportional • distinguish • emission • emit • estimate • evaluate • evidence • expand • hypothesize • infer • interact • interpret • inversely proportional • magnitude • manipulate • measure • observe • pattern • per • plausible • predict • produce • proportional • propose • qualitative • quantify • quantitative • simultaneous • spectrum • subscript • transfer • trend • valid • yields
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Chemistry

Topic ***Representing Compounds***

Content Elaborations:

Using the periodic table, formulas of ionic compounds containing specific elements can be predicted. This can include ionic compounds made up of elements from groups 1, 2, 17, hydrogen and oxygen and polyatomic ions if given the formula and charge of the polyatomic ion. Given the formula, a compound can be named using conventional systems that include Greek prefixes and Roman numerals where appropriate. Given the name of an ionic or covalent substance, formulas can be written.

Many different models can be used to represent compounds including chemical formulas, Lewis structures, and ball and stick models. These models can be used to visualize atoms and molecules and to predict the properties of substances. Each type of representation provides unique information about the compound. Different representations are better suited for particular substances. Lewis structures can be drawn to represent covalent compounds using a simple set of rules and can be combined with valence shell electron pair repulsion (VSEPR) theory to predict the three-dimensional electron pair and molecular geometry of compounds. Lewis structures and molecular geometries will only be constructed for the following combination of elements: hydrogen, carbon, nitrogen, oxygen, phosphorus, sulfur and the halogens. Organic nomenclature is reserved for more advanced courses.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Correctly write the names and formulas for ionic and covalent compounds. • Construct Lewis structures and corresponding 3-D molecular geometries.	• Organic nomenclature and functional group identification • Acid nomenclature • Draw organic compounds and resonance structures. • Discuss molecular hybridization.	• Construct 3-D models using Inventor or similar programs.

Additional Resources

Pacing

Content Vocabulary (to be assessed)	Academic Vocabulary		
• polyatomic ion	• absorption	• emission	• per
• formula	• abundance	• emit	• plausible
• Lewis structure	• analogy	• estimate	• predict
• VSEPR	• analyze	• evaluate	• produce
• nomenclature	• approximate	• evidence	• proportional
• molecular geometry	• balanced	• expand	• propose
	• calculate	• hypothesize	• qualitative
	• characteristic	• infer	• quantify
	• classify	• interact	• quantitative

Chemistry

	• coefficient • compare • continuum • correlate • criteria • directly proportional • distinguish • interpret • inversely proportional • magnitude • manipulate • measure • observe • pattern • simultaneous • spectrum • subscript • transfer • trend • valid • yields
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Chemistry

Topic	*Quantifying Matter*

Content Elaborations

In earlier grades, properties of materials were quantified with measurements that were always associated with some error. In this course, scientific protocols for quantifying the properties of matter accurately and precisely are studied. Using metric measuring systems, significant digits or figures, scientific notation, error analysis and dimensional analysis are vital to scientific communication.

There are three domains of magnitude in size and time: the macroscopic (human) domain, the cosmic domain and the submicroscopic (atomic and subatomic) domain. Measurements in the cosmic domain and submicroscopic domains require complex instruments and/or procedures.

Matter can be quantified in a way that macroscopic properties such as mass can reflect the number of particles present. Elemental samples are a mixture of several isotopes with different masses. The atomic mass of an element is calculated given the mass and relative abundance of each isotope of the element as it exists in nature. Because the mass of an atom is very small, the mole is used to translate between the atomic and macroscopic levels. A mole is used as a counting number, like a dozen. It is equal to the number of particles in exactly 12 grams of carbon-12 atoms. The mass of one mole of a substance is equal to its formula mass in grams. The formula mass for a substance can be used in conjunction with Avogadro' s number and the density of a substance to convert between mass, moles, volume and number of particles of a sample.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Conduct measurements and conversions in the three domains of magnitude using the metric system, scientific notation, error analysis, and dimensional analysis utilizing proper significant figures. • Perform calculations utilizing mass, moles, volume, number of particles (Avogadro's number), and density.	• Relate density to molar mass of a gas.	

Additional Resources

Pacing:

Content Vocabulary (to be assessed)	Academic Vocabulary		
• qualitative	• absorption	• emission	• per
• quantitative	• abundance	• emit	• plausible
• accurate	• analogy	• estimate	• predict
• precise	• analyze	• evaluate	• produce
• significant figure	• approximate	• evidence	• proportional
• error analysis	• balanced	• expand	• propose

Chemistry

• dimensional analysis • percent error • percent composition • percent yield • magnitude • macroscopic domain • cosmic domain • submicroscopic domain • atomic mass/formula mass • molar mass • isotope abundance • mole • Avogadro's number	• calculate • characteristic • classify • coefficient • compare • continuum • correlate • criteria • directly proportional • distinguish • hypothesize • infer • interact • interpret • inversely proportional • magnitude • manipulate • measure • observe • pattern • qualitative • quantify • quantitative • simultaneous • spectrum • subscript • transfer • trend • valid • yields
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Chemistry

Topic	*Phases of Matter*

Content Elaborations

In middle school, solids, liquids and gases were explored in relation to the spacing of the particles, motion of the particles and strength of attraction between the particles that make up the substance. In this course, plasmas and Bose-Einstein condensates also are included. Plasmas occur when gases have so much energy that the electrons are stripped away; therefore, they are electrically charged. In Bose-Einstein condensation the atoms, when subjected to temperatures a few billionths of a degree above absolute zero, all coalesce to lose individual identity and become a "super atom**."** Just as plasmas are super-hot atoms, Bose-Einstein condensates are the opposite – super-cold atoms (see Note). The forces of attraction between particles that determine whether a substance is a solid, liquid or gas at room temperature are addressed in greater detail with intermolecular chemical bonding later in the course.

Note: The advancement of technology makes it possible to extend the boundaries of current knowledge and understanding. Consequently, Bose-Einstein condensates were only recently created in the laboratory (1995), although predicted more than 80 years ago. Detailed instruction of Bose-Einstein condensates or plasmas is not required at this grade level. This information is strictly for recognition that new discoveries are continually occurring, extending the realm of current understanding in science.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Extend previous knowledge of solids, liquids, and gases to include new discoveries (Bose-Einstein condensates and plasmas).	• Interpret and construct phase diagrams.	

Additional Resources

Pacing:

Content Vocabulary (to be assessed)

- plasma
- Bose-Einstein condensate
- electrically charged
- absolute zero
- phase diagram
- triple point
- sublimation
- deposition
- intermolecular forces

Academic Vocabulary

- absorption
- abundance
- analogy
- analyze
- approximate
- balanced
- calculate
- characteristic
- classify
- coefficient
- compare
- emission
- emit
- estimate
- evaluate
- evidence
- expand
- hypothesize
- infer
- interact
- interpret
- inversely
- per
- plausible
- predict
- produce
- proportional
- propose
- qualitative
- quantify
- quantitative
- simultaneous
- spectrum

	• continuum • correlate • criteria • directly proportional • distinguish proportional • magnitude • manipulate • measure • observe • pattern • subscript • transfer • trend • valid • yields
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Chemistry

Topic	***Intermolecular Chemical Bonding***

Content Elaborations

In middle school, the concept of attractions between separate particles that hold molecules together in liquids and solids was introduced. These forces, called intermolecular attractions, are addressed in more detail in chemistry. Intermolecular attractions are generally weak when compared to intramolecular bonds, but span a wide range of strengths. The composition of a substance and the shape and polarity of a molecule are particularly important in determining the type and strength of bonding and intermolecular interactions. Types of intermolecular attractions include London dispersion forces (present between all molecules), dipole-dipole forces (present between polar molecules) and hydrogen bonding (a special case of dipole-dipole where hydrogen is bonded to a highly electronegative atom such as fluorine, oxygen or nitrogen), each with its own characteristic relative strengths.

The configuration of atoms in a molecule determines the strength of the forces (bonds or intermolecular forces) between the particles and therefore the physical properties (e.g., melting point, boiling point, solubility, vapor pressure) of a material. For a given substance, the average kinetic energy (and therefore the temperature) needed for a change of state to occur depends upon the strength of the intermolecular forces between the particles. Therefore, the melting point and boiling point depend upon the amount of energy that is needed to overcome the attractions between the particles. Substances that have strong intermolecular forces or are made up of three-dimensional networks of ionic or covalent bonds tend to be solids at room temperature and have high melting and boiling points. Nonpolar organic molecules are held together by weak London dispersion forces. However, substances with longer chains provide more opportunities for these attractions and tend to have higher melting and boiling points. Increased branching of organic molecules interferes with the intermolecular attractions that lead to lower melting and boiling points.

Substances will have a greater solubility when dissolving in a solvent with similar intermolecular forces. If the substances have different intermolecular forces, they are more likely to interact with themselves than the other substance and remain separated from each other. Water is a polar molecule and it is often used as a solvent since most ionic and polar covalent substances will dissolve in it. In order for an ionic substance to dissolve in water, the attractive forces between the ions must be overcome by the dipole-dipole interactions with the water. Dissolving of a solute in water is an example of a process that is difficult to classify as a chemical or physical change and it is not appropriate to have students classify it one way or another.

Evaporation occurs when the particles with enough kinetic energy to overcome the attractive forces separate from the rest of the sample to become a gas. The pressure of these particles is called vapor pressure. Vapor pressure increases with temperature. Particles with larger intermolecular forces have lower vapor pressures at a given temperature since the particles require more energy to overcome the attractive forces between them. Molecular substances often evaporate more due to the weak attractions between the particles and can often be detected by their odor. Ionic or network covalent substances have stronger forces and are not as likely to volatilize. These substances often have little if any odor. Liquids boil when their vapor pressure is equal to atmospheric pressure.

Chemistry

In solid water, there is a network of hydrogen bonds between the particles that gives it an open structure. This is why water expands as it freezes and why solid water has a lower density than liquid water. This has important implications for life (e.g., ice floating on water acts as an insulator in bodies of water to keep the temperature of the rest of the water above freezing.)		
Learning Targets	**Honors Learning Targets**	**STEM Learning Targets**
• Relate the composition of a substance, the shape, and polarity of a molecule to the types and relative strengths of intermolecular attractions (van der Waals forces). • Correlate the strength of the forces between molecules to physical properties of a material (melting point, boiling point, solubility, vapor pressure, and evaporation). • Relate the solubility of substances to the types of intermolecular forces present and molecular polarities.	• Relate intermolecular forces to properties of surface tension and viscosity. • Apply intermolecular forces to the unique properties of water.	• Relate physical properties of polymers to intermolecular forces.

Additional Resources

Pacing

Content Vocabulary (to be assessed)	Academic Vocabulary		
• molecule • atom • element • compound • London dispersion force • dipole-dipole force • hydrogen bond • van der Waals force* • solubility • vapor pressure • boiling point • melting point • sublimation point • deposition point	• absorption • abundance • analogy • analyze • approximate • balanced • calculate • characteristic • classify • coefficient • compare • continuum • correlate • criteria	• emission • emit • estimate • evaluate • evidence • expand • hypothesize • infer • interact • interpret • inversely proportional • magnitude • manipulate	• per • plausible • predict • produce • proportional • propose • qualitative • quantify • quantitative • simultaneous • spectrum • subscript • transfer • trend

Chemistry

• triple point • average kinetic energy • temperature • viscosity* • surface tension* • polar • nonpolar • solute • solvent • solution • atmospheric pressure • manometer • Pascals • atmosphere • torr • mm Hg • density	• directly proportional • distinguish • measure • observe • pattern • valid • yields
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Chemistry

Topic ***Chemical Reactions***

Content Elaborations:

In the physical science syllabus, coefficients were introduced to balance simple equations. Other representations including Lewis structures and three-dimensional models also were used and manipulated to demonstrate the conservation of matter in chemical reactions. In this course, more complex reactions will be studied, classified and represented with chemical equations and three-dimensional models. Classifying reactions into types can be a helpful organizational tool in recognizing patterns of what may happen when two substances are mixed (see Note). Some general types of chemical reactions are oxidation/reduction, synthesis, decomposition, single replacement, double replacement (including precipitation reactions and some acid-base neutralizations) and combustion reactions. Some reactions can fit into more than one category. For example, a single replacement reaction also can be classified as an oxidation/reduction reaction. Identification of reactions involving oxidation and reduction as well as indicating what substance is being oxidized and what is being reduced are appropriate in this course. However, balancing complex oxidation/reduction reactions will be reserved for more advanced study.

Organic molecules release energy when undergoing combustion reactions and are used to meet the energy needs of society (e.g., oil, gasoline, natural gas) and to provide the energy needs of biological organisms (e.g., cellular respiration). When a reaction between two ionic compounds in aqueous solution results in the formation of a precipitate or molecular compound, the reaction often occurs because the new ionic or covalent bonds are stronger than the original ion-dipole interactions of the ions in solution. Laboratory experiences (3-D or virtual) with different types of chemical reactions must be provided.

Note: Teachers should be aware that the common reaction classifications that are often used in high school chemistry courses often lead to misconceptions because they are not based on the actual chemistry, but on surface features that may be similar from one system to another (e.g., exchanging partners), even though the underlying chemistry is not the same. However, they may be useful in making predictions about what may happen when two substances are mixed.

Reactions occur when reacting particles collide in an appropriate orientation and with sufficient energy. Not all collisions are effective. Stable reactants require the input of energy, the activation energy, to initiate a reaction. A catalyst provides an alternate pathway for a reaction, usually with a lower activation energy. With this lower energy threshold, more collisions will have enough energy to result in a reaction. An enzyme is a large organic molecule that folds into a unique shape by forming intermolecular bonds with itself. The enzyme' s shape allows it to hold a substrate molecule in the proper orientation to result in an effective collision. The rate of a chemical reaction is the change in the amount of reactants or products in a specific period of time. Increasing the probability or effectiveness of the collisions between the particles increases the rate of the reaction. Therefore, changing the concentration of the reactants, the temperature or the pressure of gaseous reactants can change the reaction rate. Likewise, the collision theory can be applied to dissolving solids in a liquid solvent and can be used to explain why reactions are more likely to occur between reactants in the aqueous or gaseous state than between solids. The rate at which a substance dissolves should not be confused with the amount of solute that can dissolve in a given amount of solvent (solubility). Mathematical treatment of reaction rates are reserved for later study. Computer simulations can help visualize reactions from the perspective of the kinetic-molecular theory.

Chemistry

In middle school, the differences between potential and kinetic energy and the particle nature of thermal energy were introduced. For chemical systems, potential energy is in the form of chemical energy and kinetic energy is in the form of thermal energy. The total amount of chemical energy and/or thermal energy in a system is impossible to measure. However, the energy change of a system can be calculated from measurements (mass and change in temperature) from calorimetry experiments in the laboratory. Conservation of energy is an important component of calorimetry equations. Thermal energy is the energy of a system due to the movement (translational, vibrational and rotational) of its particles. The thermal energy of an object depends upon the amount of matter present (mass), temperature and chemical composition. Some materials require little energy to change their temperature and other materials require a great deal to change their temperature by the same amount. Specific heat is a measure of how much energy is needed to change the temperature of a specific mass of material a specific amount. Specific heat values can be used to calculate the thermal energy change, the temperature (initial, final or change in) or mass of a material in calorimetry. Water has a particularly high specific heat capacity, which is important in regulating Earth’ s temperature.

As studied in middle school, chemical energy is the potential energy associated with chemical systems. Chemical reactions involve valence electrons forming bonds to yield more stable products with lower energies. Energy is required to break interactions and bonds between the reactant atoms and energy is released when an interaction or bond is formed between the atoms in the products. Molecules with weak bonds (e.g., ATP) are less stable and tend to react to produce more stable products, releasing energy in the process. Generally, energy is transferred out of the system (exothermic) when the products have stronger bonds than the reactants and is transferred into the system (endothermic) when the reactants have stronger bonds than the products. Predictions of the energy requirements (endothermic or exothermic) of a reaction can be made given a table of bond energies. Graphic representations can be drawn and interpreted to represent the energy changes during a reaction, including the activation energy. The roles of energy and entropy in determining the spontaneity of chemical reactions are dealt with conceptually in this course. Avoid describing entropy as the amount of disorder since this leads to persistent misconceptions. Mathematical treatment of entropy and its influence on the spontaneity of reactions is reserved for advanced study.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Classify chemical reactions (oxidation-reduction, synthesis, decomposition, single replacement, double replacement, combustion, and neutralization). • Relate the occurrence of chemical reactions to the energies and relative bond strengths of the reactants and the products. • Examine the collision theory of reactions and the roles of catalysts and enzymes in reaction rates. • Distinguish between exothermic and endothermic reactions. • Construct a graphic representation of	• Use enthalpy and entropy calculations to determine if a reaction is thermodynamically favorable. • Calculations of equilibrium for reversible reactions, solubility of ionic salts, and acids/bases. • BrØnsted-Lowry and Lewis acids and bases. • Assign oxidation numbers. • Balance redox reactions. • Apply redox reactions to an electrochemical cell. • Calculate heat transfer in a chemical reaction using Hess's Law and heats of formation.	• Apply redox reactions to an electrochemical cell. • Analyze thermal insulating and conducting properties of materials.

energy changes. • Calculate heat transfer in a chemical reaction using calorimetry. • Calculate the heat transfer during a phase change. • Relate the concentrations of reactants and products in a reversible reaction to chemical equilibrium and conditions (temperature, pressure, concentration) that change the equilibrium and reaction rate. • Assess the ability of acids and bases to dissociate using calculations and lab procedures. • Use enthalpy and entropy to determine if a reaction is thermodynamically favorable.	• Discuss basic organic reactions.	

Additional Resources

Pacing

Content Vocabulary (to be assessed)			Academic Vocabulary		
• coefficient • Lewis structure • organic • oxidation reduction • synthesis • decomposition • single replacement • double replacement • neutralization • precipitation • combustion • spectator ion • net ionic equation • complete ionic	• kinetic molecular theory • enzyme • catalyst • collision theory • activation energy • transition state • substrate • reactants • products • concentration • effective collision • orientation • reaction rate • substrate	• calorimetry • potential energy • kinetic energy • specific heat • bond energy • heat of formation • exothermic • endothermic • entropy* • enthalpy* • spontaneity • Gibbs free energy • BrØnsted-Lowry acid/base • Lewis acid/base	• absorption • abundance • analogy • analyze • approximate • balanced • calculate • characteristic • classify • coefficient • compare • continuum • correlate • criteria • directly	• emission • emit • estimate • evaluate • evidence • expand • hypothesize • infer • interact • interpret • inversely proportional • magnitude • manipulate • measure	• per • plausible • predict • produce • proportional • propose • qualitative • quantify • quantitative • simultaneous • spectrum • subscript • transfer • trend • valid

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<tr><td>equation
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• equilibrium
• Hess's Law</td><td>proportional
• distinguish
• observe
• pattern
• yields</td></tr>
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Homework Assignments
Labs
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Math: Continuous use of algebraic manipulation and practical applications
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Chemistry

Topic *Gas Laws*

Content Elaborations

The kinetic-molecular theory can be used to explain the macroscopic properties of gases (pressure, temperature and volume) through the motion and interactions of its particles. When one of the three properties is kept constant, the relationship between the other two properties can be quantified, described and explained using the kinetic-molecular theory. Real-world phenomena (e.g., why tire pressure increases in hot weather, why a hot air balloon rises) can be explained using this theory. Problems also can be solved involving the changes in temperature, pressure and volume of a gas. When solving gas problems, the Kelvin temperature scale must be used since only in this scale is the temperature directly proportional to the average kinetic energy. The Kelvin temperature is based on a scale that has its minimum temperature at absolute zero, a temperature at which all motion theoretically stops. Since equal volumes of gases at the same temperature and pressure contain an equal number of particles (Avogadro's law), problems can be solved for an unchanging gaseous system using the ideal gas law ($PV = nRT$) where R is the ideal gas constant (e.g., represented in multiple formats, 8.31 Joules / (mole K). The specific names of the gas laws are not addressed in this course. Deviations from ideal gaseous behavior are reserved for more advanced study. Explore the relationships between the volume, temperature and pressure in the laboratory or through computer simulations or virtual experiments.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Utilize the kinetic-molecular theory to explain the properties of gases (pressure, temperature, volume) and the relationships between them, integrating concrete applications. • Perform calculations and experiments using gas laws.	• Compare and contrast real and ideal gases. • Calculate partial pressures of gases using Dalton's Law. • Calculate rates of diffusion and effusion of gases using Graham's Law.	

Additional Resources

Pacing

Content Vocabulary (to be assessed)	Academic Vocabulary		
• real gas	• absorption	• emission	• per
• ideal gas law constant	• abundance	• emit	• plausible
• combined gas law	• analogy	• estimate	• predict
• partial pressure	• analyze	• evaluate	• produce
• PV = nRT (ideal gas law)	• approximate	• evidence	• proportional
• diffusion	• balanced	• expand	• propose
• effusion	• calculate	• hypothesize	• qualitative
• standard temperature and pressure (STP)	• characteristic	• infer	• quantify
	• classify	• interact	• quantitative

Chemistry

	• coefficient • compare • continuum • correlate • criteria • directly proportional • distinguish • interpret • inversely proportional • magnitude • manipulate • measure • observe • pattern • simultaneous • spectrum • subscript • transfer • trend • valid • yields
Formative Assessments Homework Assignments Labs Quizzes	**Summative Assessments** Unit Tests Lab Practicals
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Chemistry

Topic	*Stoichiometry*

Content Elaborations

A stoichiometric calculation involves the conversion from the amount of one substance in a chemical reaction to the amount of another substance. The coefficients of the balanced equation indicate the ratios of the substances involved in the reaction in terms of both particles and moles. Once the number of moles of a substance is known, amounts can be changed to mass, volume of a gas, volume of solutions and/or number of particles. Molarity is a measure of the concentration of a solution that can be used in stoichiometric calculations. When performing a reaction in the lab, the experimental yield can be compared to the theoretical yield to calculate percent yield. The concept of limiting reagents is treated conceptually and not mathematically. Molality and Normality are concepts reserved for more advanced study.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Perform stoichiometric calculations (i.e., molarity, gas laws, mass-mass, mass-mole, etc.). • Using experimentation, calculate percent yield. • Examine the concept of limiting reagents conceptually and mathematically. • Discuss the levels of solubility (saturation, miscibility).	• Perform calculations utilizing molality and mole fraction. • Examine colligative properties and perform associated calculations with bp elevation, fp depression, vapor pressure depression.	• Investigate the formation of crystals in solution.

Additional Resources

Pacing:

Content Vocabulary (to be assessed)	Academic Vocabulary		
• stoichiometric	• absorption	• emission	• per
• ratio	• abundance	• emit	• plausible
• molarity	• analogy	• estimate	• predict
• molality	• analyze	• evaluate	• produce
• theoretical yield	• approximate	• evidence	• proportional
• percent yield	• balanced	• expand	• propose
• colligative property*	• calculate	• hypothesize	• qualitative
• experimental yield	• characteristic	• infer	• quantify
• limiting reagent	• classify	• interact	• quantitative
• excess reagent	• coefficient	• interpret	• simultaneous
• boiling point elevation*	• compare	• inversely proportional	• spectrum
• freezing point depression*	• continuum		• subscript

• vapor pressure depression* • saturated • unsaturated • supersaturated • crystallization • mole fraction* • misible • immiscible	• correlate • criteria • directly proportional • distinguish • magnitude • manipulate • measure • observe • pattern • transfer • trend • valid • yields
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Chemistry

Topic	*Nuclear Reactions*

Content Elaborations

The basics of nuclear forces, isotopes, radioactive decay, fission and fusion were addressed in the physical science syllabus. In chemistry, specific types of radioactive decay and using nuclear reactions as a source of energy are addressed. Radioactive decay can result in the release of different types of radiation (alpha, beta, gamma, positron) each with a characteristic mass, charge and potential to ionize and penetrate the material it strikes. Beta decay results from the decay of a neutron and positron decay results from the decay of a proton. When a radioisotope undergoes alpha, beta or positron decay, the resulting nucleus can be predicted and the balanced nuclear equation can be written.

Nuclear reactions, such as fission and fusion, are accompanied by large energy changes that are much greater than those that accompany chemical reactions. These nuclear reactions can theoretically be used as a controlled source of energy in a nuclear power plant. There are advantages and disadvantages of generating electricity from fission and fusion.

Learning Targets	Honors Learning Targets	STEM Learning Targets
• Identify the types of radioactive decay, particles released, and relative ionization and penetrability. • Predict and balance nuclear equations. • Discuss the power-generating capability of fusion and fission.	• Apply nuclear chemistry, such as radio tracers, to the medical field. • Discuss the composition of subatomic particles in terms of quarks.	

Additional Resources

Pacing:

Content Vocabulary (to be assessed)

- alpha particle
- beta particle
- chain reaction
- fission
- fusion
- gamma ray
- Geiger counter
- nuclear force
- nuclear reactor
- positron
- quark*
- radiation
- radio tracer
- radioactive decay

radioisotope

Academic Vocabulary

- absorption
- abundance
- analogy
- analyze
- approximate
- balanced
- calculate
- characteristic
- classify
- coefficient
- compare
- emission
- emit
- estimate
- evaluate
- evidence
- expand
- hypothesize
- infer
- interact
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- inversely
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- plausible
- predict
- produce
- proportional
- propose
- qualitative
- quantify
- quantitative
- simultaneous
- spectrum

Chemistry

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