Kutztown Area School District Curriculum (Unit Map)

High School Chemistry
Written by Luke Bricker

Course Description: This introductory course is designed for students intending to pursue postsecondary studies. The curriculum covers basic chemistry concepts (e.g. atomic structure, electronic structure, periodic trends, bonding theories, chemical nomenclature, reactions and stoichiometry) supported by real-time data collection and analysis.

Table of Contents

Unit #/Title	1/Measurements and Dimensional Analysis	Time Frame	3 Weeks

Standards	
3.2.10.A4. Explain the difference between endothermic and exothermic reactions. **3.2.10.A1.** Identify properties of matter that depend on sample size.	
Big Ideas	**Essential Questions**
• Chemistry is an experimental science that uses a systematic means for posing and testing solutions to questions of the world. • Scientists, including chemists, systematically collect and analyze data in a variety of ways to determine how matter interacts.	• What are the general steps in scientific inquiry? • How do scientists evaluate the quality of the results of an experiment?
Content	**Skills**
• Measurements are the complex foundation of experiments and are dependent on the precision and uncertainty of the measuring device. • The International System (SI) is preferred by the scientific community; however, the algebraic technique of dimensional analysis can be used to easily move from one system to another. • Chemists often work with extremely large and small numbers that necessitate the use of scientific notation. • Scientific theories are used to explain the qualitative and quantitative relationships observed during experimentation. • Experimental results can be evaluated using a variety of mathematical techniques • Chemical reactions are accompanied by corresponding energy changes that can be summarized using energy-level diagrams (i.e. reaction profiles).	• Correctly take physical measurements using a variety of measuring devices with differing uncertainties. • Apply the uncertainties of individual measurements to determine maximum and minimum results calculated from those measurements. • Round measurements and calculated values using rules for significant digits. • Convert measurements from decimal notation to scientific notation and vice versa. • Perform calculations (with and without a calculator) using multiplication and division rules for scientific notation. • Convert from one unit of measurement to another using appropriate conversion (or unit) factors. • Collect appropriate experimental data, use raw data to perform meaningful calculations, and draw theory-related conclusions from experimental results. • Evaluate experimental results for their precision and accuracy using mathematical operations. • Explain exothermic and endothermic reactions in terms of energy and graphic representations, known as reaction profiles or energy-level diagrams.

Unit #/Title	2.1/States of Matter & Thermodynamics	**Time Frame**	2 Weeks

Standards

3.2.C.A1. Differentiate between physical properties and chemical properties.
3.2.C.A3. Describe the three normal states of matter in terms of energy, particle motion and phase transitions.
3.2.10.A3. Describe phases of matter according to the kinetic molecular theory.
3.2.C.B3. Explain the difference between an endothermic process and an exothermic process.
3.2.12.B3. Describe the relationship between the average kinetic energy, temperature and phase changes.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.
3.2.10.B2. Explain how the overall energy flow through a system remains constant.
3.2.10.B3. Analyze the processes of convection, conduction and radiation between objects or regions that are at different temperatures.
3.2.C.B3. Describe the law of conservation of energy.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Chemistry is the study of matter and the changes it undergoes.
- Changes in matter are accompanied by changes in energy.
- The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes of matter.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

Essential Questions

- How do models of non-visible particles help scientists understand and explain macroscopic properties of matter?
- What is the relationship between energy and the positioning and movement of non-visible particles?

Content

- Chemistry is the study of matter, its properties and how it changes.
- There are three basic states of matter, each of which has its own unique macroscopic and molecular properties.
- The properties of matter can be broken down into two different categories: physical properties and chemical properties.
- Energy takes on many different forms.
- Kinetic energy is the energy of motion and is directly related to the speed of the particles.
- Potential energy is the energy of position and is directly related to the distance between particles.
- Kinetic molecular theory is used to describe the motion and position of particles of matter
- Matter changes from one state to another by absorbing or losing energy.
- Energy cannot be created nor destroyed, but rather it changes from one form to another. These changes in energy are predictable and can be evaluated using mathematical relationships.

Skills

- Calculate the heat, specific heat capacity, mass, or temperature change associated with a change in kinetic energy.
- Calculate the heat, latent heat change, or mass associated with a change in potential energy.
- Evaluate warming/cooling curves and describe the unique sections using kinetic molecular theory.
- Apply kinetic molecular theory to explain changes in temperature and/or state as well as particular motion and position.
- Collect real-time temperature data and use graphic representations to explain energy changes associated with the absorption (or release) of energy in the form of heat.

Unit #/Title	2.2/Calorimetry	Time Frame	1-2 Weeks

Standards

3.2.10.B2. Explain how the overall energy flow through a system remains constant.
3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of convection, conduction and radiation between objects or regions that are at different temperatures.
3.2.C.B3. Describe the law of conservation of energy.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.
3.2.P.B3. Explain how energy flowing through an open system can be lost.

Big Ideas	Essential Questions
• Chemists use the flow of energy in isolated systems and appropriate measurements to evaluate the chemical and physical properties of matter. • Carefully collected data and algebraic relationships can be used to confirm the properties of matter and support scientifically accepted theories.	• How do scientists evaluate the energy changes associated with chemical and physical processes? • How do scientists create isolated systems that provide environments where relationships between properties can be experimentally determined?

Content	Skills
• Calorimetry is the science of measuring heat flow due to differences in energy. • Many of the physical properties of matter can be determined experimentally using the process of calorimetry. • A calorimeter is an insulated device that creates the closed-system necessary to evaluate energy flow. • First Law of Thermodynamics explains that the energy of a closed system remains constant (i.e. energy cannot be created nor destroyed). • The physical properties of matter are algebraically related, providing a means for predicting and/or calculating other unknown physical properties.	• Evaluate a variety of physical properties (specific heat capacity and latent enthalpy of vaporization) using the process of calorimetry. • Explain different types of physical changes (sensible and latent) in terms of energy, particle movement and motion, algebraic relationships, and graphic representations. • Collect and use experimental data to confirm the scientifically accepted values of physical properties.

Unit #/Title	2.3/Gases	Time Frame	1-2 Weeks

Standards	
3.2.10.A3. Describe phases of matter according to the kinetic molecular theory. **3.2.10.B3**. Analyze the processes of convection, conduction and radiation between objects or regions that are at different temperatures. **3.2.10.B6.** Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.	
Big Ideas	**Essential Questions**
• The properties of gases are unique when compared to other states of matter; however, the relationships between properties can be explained similar fashion using models of positioning and movement of atoms/ions/molecules. • The early studies of gases became the foundation for the development of atomic theory and our progressive understanding of chemical properties and reactions.	• How do the properties of gases relate to one another in the predictable fashion that humans use in a variety of applications? • How are the properties of gases explained using particulate models and algebraic relationships?
Content	**Skills**
• Gases have unique physical properties that make them significantly different from liquids and solids. • The physical properties (volume, pressure, and absolute temperature) of gases are all associated with one another via simple algebraic relationships. • Pressure is caused by collision of gas particles with a surface and its magnitude is dependent on the frequency of those collisions and their force. • The development and application of the absolute temperature scale developed from experimental data relating a gas' volume to its temperature. • Kinetic Molecular Theory can be used to explain changes in the physical properties (volume, pressure, or absolute temperature) of gases due to changes in other properties (volume, pressure, or absolute temperature).	• Describe changes in gas properties and relationships in terms of the movement of gas particles. • Evaluate/predict the relationships of gas properties using algebraic expressions. • Understand the relationships between mathematical calculations, graphic representations, models, and theory. • Collect real-time temperature data and use graphical representations to confirm the validity of gas laws (Boyle's, Charles', and Amontons').

Unit #/Title	3/Atomic Theory	**Time Frame**	2 Weeks

Standards

3.2.10.A2. Explain why compounds are composed of integer ratios of elements.
3.2.C.A2. Determine percent compositions, empirical formulas, and molecular formulas.
3.2.C.A1. Differentiate between pure substances and mixtures; differentiate between heterogeneous and homogeneous mixtures.
3.2.C.A4. Predict how combinations of substances can result in physical and/or chemical changes. Interpret and apply the laws of conservation of mass, constant composition (definite proportions) and multiple proportions.
3.2.10.A5. Describe the historical development of models of the atom and they contributed to modern atomic theory.
3.2.C.A5. Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus) and Bohr (planetary model of atom), and discovery leads to modern atomic theory.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas	**Essential Questions**
• Atomic theory is the foundation for the study of chemistry • The limitations and historical advancements of scientific technology have played a significant role in mankind's understanding of matter.	• What resources were used to develop John Dalton's Atomic Theory? • How did the individual postulates of Dalton's Atomic Theory develop into more significant ideals in the scientific world?

Content	**Skills**
• John Dalton's Atomic Theory was developed as a result of scientific advancements and served as the historical starting point for our understanding of atoms. • Matter can be broken down into two categories: pure substances and mixtures. • Pure substances can be broken down into two categories: elements and compounds. • Elements are composed of tiny particles called atoms and compounds are composed of atoms of different elements that are chemically bound, creating entirely new substances. • The properties of compounds are independent of the properties of the atoms they are comprised of. • Mixtures can be separated, or purified, by utilizing differences in physical properties between elements/compounds due to the fact that in a mixture each of the components retains its own properties.	• Separate a mixture of table salt and water using simple distillation and identify the components using physical properties. • Separate a mixture of ethanol and water using simple distillation and identify the components using both physical and chemical properties. • Separate and evaluate (calculate retention factors) the components of commercial markers using the technique of paper chromatography. • Design experiments capable of successfully separating a variety of mixtures, utilizing differences in physical properties.

Unit #/Title	4/Modern Atomic Theory	Time Frame	2 Weeks

Standards

3.2.12.A2. Distinguish among the isotopic forms of elements.
3.2.10.A5. Describe the historical development of models of the atom and they contributed to modern atomic theory.
3.2.C.A5. Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus) and Bohr (planetary model of atom), and discovery leads to modern atomic theory. Describe Rutherford's "gold foil" experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, electrons) of the nuclear atom and explain how they interact.
3.2.12.B4. Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Atomic theory is the foundation for the study of the properties of matter and how it changes.
- Technological advancements lead to experimental results capable of deepening our understanding of matter/energy and provide the means for revising prior beliefs.

Essential Questions

- How has our understanding of matter changed due to the results of experiments performed throughout history?
- What impact do technological advancements have on our understanding of matter/energy?

Content

- The development of Modern Atomic Theory evolved from the results of experimentation performed by JJ Thomson, Robert Millikan, and Ernest Rutherford.
- Technological advancements and the accumulation of experimental results (from around the World) improve human understanding.
- The experiments of JJ Thomson, Robert Millikan, and Ernest Rutherford confirmed the existence of sub-atomic particles -- with unique properties and positioning within an atom -- and disproved prior beliefs about matter on this level.
- Scientists created the atomic mass unit (amu) to more conveniently deal with matter on atomic and sub-atomic levels.
- The number of protons in an atom determine the type of element of the atom and is referred to as the atomic number.
- The sum of protons and neutrons in the nucleus of an atom is known as the mass number.
- Atoms of the same element with differing numbers of neutrons (and masses) are known as isotopes.
- Atomic weights found on the Periodic Table are actually average atomic weights calculated as weighted averages of all the naturally occurring isotopes of an element.
- The carbon-12 atom is the standard by which all atomic weights (molar masses) are determined and carbon-14 is the isotope of carbon whose radioactive decay is used for carbon-dating.

Skills

- Represent an atom in terms of its atomic number number, mass number, and charge.
- Determine atomic numbers, mass numbers, charges, electron configuration, and elemental identities given other characteristics of an atom.
- Calculate the average atomic weight of an element given the relative abundances and corresponding atomic weights of all naturally occurring isotopes.
- Calculate abundances of isotopes given the average atomic of an element and the atomic weights of all naturally occurring isotopes.
- Apply the law of definite proportions to experimentally determine the mass percentage of an element in a compound and the atomic weight of an unknown metal.

• The movement and position of electrons determines the chemical properties of an atom. • Chemical reactions can be categorized by the relative numbers of reactants and products and gravimetric analysis -- which uses changes in mass -- can be used to determine properties of the chemicals involved.	

Unit #/Title	4.5/Elemental Conversions	**Time Frame**	2 Weeks

Standards	
3.2.C.A2. Use the mole concept to determine the number of particles and molar mass for elements and compounds. **3.2.10.A5.** Apply the mole concept to determine number of particles and molar mass for elements and compounds.	
Big Ideas	**Essential Questions**
• The amount of matter present in a sample can be represented in a multitude of ways and mathematical operations allow for the conversion from one means to another. • The Periodic Table contains properties of elements that can be used to represent the amount of an element in a sample using a variety of algebraic calculations.	• What are the different means by which scientists represent the amount of a chemical present?
Content	**Skills**
• The mole is the SI unit for amount and it represents the number of atoms found in exactly 12 grams of carbon-12 (standard). • A mole represents 6.022 x 10^{23} particles (known as Avogadro's number). • Elemental conversions can be accomplished by using the relationships between molar masses and the number of particles found in a mole. • The atomic weights on the Periodic Table are weighted averages of all naturally occurring isotopes of the element.	• Calculate the number of moles, atoms, or mass of an element present from provided information. • Use mass ratios to determine the properties (e.g. molar mass, atomic weight, etc.) of an element. • Determine the average atomic weight of an element or the relative abundance of all naturally occurring isotopes, given sufficient information.

Unit #/Title	5/Light	Time Frame	3 Weeks

Standards

3.2.10.B3. Analyze the processes of convection, conduction and radiation between objects or regions that are at different temperatures.
3.2.10.B5. Understand that waves transfer energy without transferring matter. Compare and contrast the wave nature of light and sound. Describe the components of the electromagnetic spectrum. Describe the difference between sound and light waves.
3.2.P.B5. Explain how waves transfer energy without transferring mass. Describe the cause of wave frequency, speed, and wavelength.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws

Big Ideas

- Scientists' understanding of the positioning and movement of electrons in atoms originated from the observed properties of light and the realization that light and matter -- while in some ways are different -- share important properties.
- Light is a form of energy the travels through space without moving mass.

Essential Questions

- How have the properties of light provided scientists with a more thorough understanding of the movement and positioning of sub-atomic particles within an atom?
- What are the relationships between the different properties of light and how do they relate to the observable?

Content

- Light is a form of energy that exhibits a dual nature (particles and wave) that depends on the application.
- The electromagnetic spectrum is large and visible light makes up only a small portion of the full spectrum.
- All waves have corresponding properties (wavelength, amplitude, and frequency).
- Mechanical waves (e.g. ocean waves, sound waves, etc.) require a medium and are caused by the by colliding matter.
- The properties of light (speed, frequency, wavelength, and energy per photon) are associated to one another via simple algebraic relationships.
- Most light is comprised of more than one wavelength, like a mixture, and can be separated using either diffraction or refraction.
- When light is separated it creates one of two types of spectra (full or line).
- Neils Bohr developed his model of the hydrogen atom based on the line spectrum produced by the excited hydrogen atoms, caused by the movement of the electron in the atom.
- The energy of shells can be algebraically determined and the energy change associated with transitions from one shell to another can be used to identify the wavelength of light associated with the transition.
- Louis De Broglie hypothesized that anything that has mass and a velocity (momentum) travels in a corresponding wave, which was confirmed based on the diffraction of x-rays by atoms; however, waves of

Skills

- Identify and explain the different types of electromagnetic radiation using real-world experiences and algebraic calculations.
- Describe the similarities and differences between electromagnetic waves and mechanical waves.
- Calculate properties of light, including wavelength, frequency, and the energy per photon.
- Calculate the energies of shells, the energy changes associated with electron transitions, and the wavelength of light associated with energy loss/gain in one-electron systems.
- Explain the loss and gain of energy in an atom conceptually and quantitatively.
- Evaluate the momentum and/or wavelength of matter traveling at a given velocity.
- Identify an unknown solution using light emission.
- Experimentally determine an appropriate wavelength for evaluating the concentration of a solution.

macroscopic matter are so small that they are invisible to the human eye. • Light can be used to evaluate the concentrations of solutions based on the absorbance and transmittance of specific wavelengths of light. • Solutions are like filters, whose appearance is based on what wavelengths of light are absorbed and which are transmitted. • An absorbance spectrum demonstrates the wavelengths of light that are absorbed by a given solution and the magnitude of the absorbance level. • A standard curve (absorbance versus concentration) can be used to determine the concentration of a solution of unknown solute content.	

Unit #/Title	6/Electronic Structure	Time Frame	3 Weeks

Standards

3.2.C.A2. Compare the electron configuration for the first twenty elements of the periodic table.
3.2.12.A2. Explain how light is absorbed or emitted by electron orbital transitions.
3.2.C.A5. Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus) and Bohr (planetary model of atom), and discovery leads to modern atomic theory.
3.2.12.B4. Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas	Essential Questions
• Chemists use a variety of ways to represent the location of electrons in an atom to explain the chemical and physical properties of the elements. • Bohr's model of the hydrogen atom proved to be incapable of explaining multi-electron systems and a more complex, mathematical model is now accepted in describing the position and motion of electrons in atoms.	• How did Bohr's model of the hydrogen atom provide the foundation for the more complicated wave-mechanical model, currently acknowledge by chemists? • What are the different ways that chemists represent the position and movement of electrons in atoms and under what applications are each preferred?

Content	Skills
• The quantum mechanical model of electron positioning uses three-dimensional calculus and accounts for the wave-like movement of electrons around the nucleus. • It is impossible to know both the position and momentum of an electron in an atom; thus, the quantum mechanical model is only capable of identifying the likelihood of finding an electron at a given position. • The quantized energy levels in the quantum mechanical model are known as orbitals, which is a revision from the Bohr's model that was only able to explain one-electron systems. • All orbitals, regardless of shape, are capable of holding two electrons spinning in opposite directions. • Every electron can be expressed in terms of four quantum numbers that indicate the shell, subshell (or orbital type), orientation in space, and electron spin. • Orbitals are filled from lowest energy to highest energy and follow general rules within subshells. • Orbitals have differing shapes that depend on the type of subshell (s, p, d, or f) they are located in. • Each type of subshell holds a unique number of orbitals. • Each shell holds a unique combination of subshells and thus differing numbers of orbitals and electrons. • Chemists represent the electron structure of atoms using two methods (electron configuration and orbital diagrams).	• Use quantum numbers to determine the location of electrons in an atom. • Use the Periodic Table to express all elements in terms of their electron configurations, orbital diagrams, and Lewis dot notations.

• Electronic structure can be easily determined based off of position on the Periodic Table.	

Unit #/Title	6.5/Periodic Trends	Time Frame	2 Weeks

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table.
3.2.C.A1. Explain the relationship of an element's position on the periodic table to its atomic number, ionization energy, electronegativity, atomic size, and classification of elements.
3.2.C.A2. Compare the electron configuration for the first twenty elements of the periodic table. Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas	Essential Questions
• Periodic trends in the properties of atoms allow for the prediction of physical and chemical properties. • Elements are placed systematically on the Periodic Table in a fashion that allows for predicting the properties of an element solely based on position.	• How can the position of an element on the Periodic Table be used to predict the chemical and physical properties of atoms of the element?

Content	Skills
• The placement of elements on the Periodic Table was purposefully done and can be used to predict physical and chemical properties of the element. • Elemental trends on the Periodic Table can be explained using electrostatic attraction and Coulomb's law, which states that the force between charged particles is directly proportional to the magnitude of their charges and inversely proportional to the square of the distance between them. • Atomic radius decreases from left to right, due to increase in effective nuclear charge, and increases from top to bottom, due to the increasing number of occupied shells. • Ionization energy is associated with the removal of an electron from an atom and it increases from left to right, due to increasing effective nuclear size and charge, and decreases from top to bottom, due to increasing distance from the nucleus. • Electron affinity is associated with the addition of an electron to an atom and it increases from left to right (excluding Noble gases) and decreases from top to bottom. • Electronegativity is associated with an atom's attraction for electrons that are being shared in a bond and it increases from left to right and decreases from top to bottom.	• Calculate the effective nuclear charge reaching the valence shell of all atoms, based on periodic positioning. • Use periodic position to determine the number of valence shell electrons and occupied shells of all atoms. • Identify the names of the families on the Periodic Table. • Explain each of the four major trends (Atomic Radius, Ionization Energy, Electron Affinity, and Electronegativity) in terms of effective nuclear charge reaching the valence shell and occupied shells.

Unit #/Title	7/Ionic Compounds	**Time Frame**	2 Weeks

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table.
3.2.C.A1. Explain the relationship of an element's position on the periodic table to its atomic number, ionization energy, electronegativity, atomic size, and classification of elements.
3.2.10.A2. Compare and contrast different bond types that result in the formation of molecules and compounds.
3.2.C.A2. Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table. Explain how atoms combine to form compounds through ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons. Draw Lewis dot structures for simple molecules and ionic compounds. Predict the chemical formulas for simple ionic and molecular compounds.
3.2.12.B4. Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Chemical bonding occurs as a result of attractive forces between particles.
- Chemical reactions are predictable.
- The chemical elements are fundamental building materials of matter and all can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
- Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Essential Questions

- How do metals and non-metals form chemical bonds that explain the unique properties of the resulting compounds?
- How do individual energy changes relate to the overall energy changes that occur when a sequence of chemical processes takes place?

Content

- When atoms of metals and nonmetals react with one another there is a complete transfer of valence electrons that creates ions of opposite charges that are electrostatically attracted to one another.
- Metals tend to lose their valence electrons, creating a positively charged ions (cations) with noble gas configuration (i.e. octet).
- Nonmetals tend to gain electrons in their valence shell, creating negatively charged ions (anions) with noble gas configuration.
- A cation is approximately half the size of its mother atom and an anion is approximately double the size its mother atom.
- The electrostatic attraction between ions is known as an ionic bond and the compound produced is known as an ionic compound.
- Ionic bonds are strong, non-directional forces of attraction that can be used to explain the unique properties of ionic compounds.

Skills

- Identify the charges (i.e. oxidation states) all atoms acquire -- when they become ions -- based on periodic position.
- Predict the chemical formula of an ionic compound based on the charges of the bonding ions.
- Apply the law of conservation of mass by balancing ionic synthesis reactions.
- Compare ionic bond strengths by applying Coulomb's law.
- Write the individual reactions necessary to create a Born-Haber cycle energy-level diagram.
- Perform a gravimetric analysis to confirm the law of conservation of mass using a precipitation reaction.

• Ionic bond strength is explained using Coulomb's law, which states that the force of attraction between oppositely charged ions is directly proportional to the magnitude of the charges and inversely proportional to the square of the distance between them. • The sequence of chemical processes required in order to create an ionic compound from standard state elements can be summarized energetically using a Born-Haber cycle. • Precipitation reactions are chemical reactions in which solutions containing two soluble ionic compounds are mixed to produce an insoluble ionic compound, known as the precipitate, and a soluble ionic compound that remains in the supernatant liquid.	

Unit #/Title	8/Molecular Compounds	Time Frame	2-3Weeks

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table.
3.2.C.A1. Explain the relationship of an element's position on the periodic table to its atomic number, ionization energy, electronegativity, atomic size, and classification of elements. Use electronegativity to explain the difference between polar and non-polar covalent bonds.
3.2.10.A2. Compare and contrast different bond types that result in the formation of molecules and compounds.
3.2.C.A2. Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table. Explain how atoms combine to form compounds through ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons. Draw Lewis dot structures for simple molecules and ionic compounds. Predict the chemical formulas for simple ionic and molecular compounds.
3.2.12.A5. Use VSEPR theory to predict the molecular geometry of molecules.
3.2.12.B4. Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Chemical bonding occurs as a result of attractive forces between particles.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
- Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Essential Questions

- How do nonmetal atoms bond differently from metal atoms, creating the the observed differences in properties?
- How does the bonding between atoms relate to the energy changes that occur when chemical reactions take place?

Content

- When nonmetals bond with one another electrons are not transferred, rather they are shared due to a more equal attraction for the electrons.
- Compounds produced only of non metals are comprised of molecules.
- The sharing of valence electrons is known as as covalent bond and both bonding atoms are able to obtain noble gas configuration (an octet).
- When identical atoms share electrons the resulting covalent bond is known as a pure, or nonpolar covalent bond.
- When non-identical atoms share electrons the resulting bond is known as a polar covalent bond due to the unequal sharing (or uneven distribution).
- Covalent bonds are created when the orbitals of atoms overlap one another creating molecular orbitals from atomic orbitals.
- The formation of a covalent bond is due to a decrease in potential energy, which is equivalent to the bond energy, and the distance between the bonding atoms is known as the bond length.

Skills

- Draw Lewis structures for simple molecules based on periodic position.
- Predict the shapes, bond angles, and polarity of molecules by applying VSEPR.
- Assign bond dipoles to covalent bonds.
- Identify the polarity of a molecule based on bond polarity and three-dimensional orientation in space.
- Calculate the enthalpy change for a reaction using the bond energies of reactants and products.
- Explain why it requires energy to break covalent bonds and why energy is released when covalent bonds are formed.
- Predict bond strengths and bond lengths based on the number of shared electrons and the polarity of bonds.
- Explain the energy decrease resulting from covalent bond formation using forces of attraction and repulsion (e.g. hydrogen molecule).

• Bond length is dependent the number of electrons being shared between two atoms (e.g. single bond vs. double bond, etc.) and inversely proportional to bond strength. • Hybridization is the scientific explanation of molecular shapes and is determined by the number and types of bonds around a central atom. • Hybridization is the blending of valence atomic orbitals (s and p) to create hybrid orbitals of the same energy, capable of maximizing the number of unpaired electrons and equivalent bonds and atom can make. • Unhybridized p orbitals allow atoms to create more than one bond between atoms. • The first covalent bond that forms between any two atoms occurs on the internuclear access and is called a sigma bond. • The second covalent bond that forms between any two atoms occurs outside the internuclear access - using unhybridized p orbitals - and is called a pi bond. • The hybridization of the atomic orbitals of the central atom and the number of bonds created determines the shape of the molecule and the bonds angles present in the molecule. • The polarity of a molecule is dependent on the types of covalent bonds present in the molecule and the three-dimensional symmetry. • The enthalpy change of reaction is due to the breaking of old bonds (endothermic process) and the creation of new bonds (exothermic process) and can be estimated using bond energies.	

Unit #/Title	8.5/Chemical Calculations	Time Frame	4 Weeks

Stage 1 - Identify Desired Results	
Standards	
3.2.C.A2. Use the mole concept to determine the number of particles and molar mass for elements and compounds. Determine percent compositions, empirical formulas and molecular formulas.	
Big Ideas	**Essential Questions**
• Calculations for compounds are performed similarly to those of individual elements and serve as the quantitative means for predictions of chemical processes?	• How do chemists evaluate the amounts of chemicals present in a sample?
Content	**Skills**
• A mole of a chemical is the same as a mole of an element; however, the mass equivalent is the sum of the individual elements present in the compound. • Empirical formulas represent the lowest whole-number ratio of elements in a compound and molecular formulas represent the actual number of atoms of each type in a molecule of a molecular compound (only). • Chemical formulas are often determined using known chemical reactions and gravimetric analysis of the chemical.	• Calculate the number of moles, atoms/formula units/molecules, or mass of an compound present from provided information. • Use gravimetric data to determine empirical and molecular formulas.

Unit #/Title	9/Intermolecular Forces and Solutions	Time Frame	2-3 Weeks

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table. Explain the unique properties of water (polarity, high boiling-point, forms hydrogen bonds) that support life on Earth.
3.2.C.A1. Use electronegativity to explain the difference between polar and nonpolar covalent bonds.
3.2.12.A1. Compare and contrast the unique properties of water to other liquids.
3.2.C.A2. Explain how atoms combine to form compounds through ionic and covalent bonding. Draw Lewis dot structures for simple molecules and ionic compounds.
3.2.10.A4. Explain the difference between endothermic and exothermic reactions.
3.2.12.A5. Use VSEPR theory to predict the molecular geometry of molecules.
3.2.10.B2. Explain how the overall energy flow through a system remains constant.
3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.
3.2.C.B2. Explore the natural tendency for systems to move in a direction of disorder or randomness (entropy).
3.2.C.B3. Describe the law of conservation of energy. Explain the difference between an endothermic process and an exothermic process.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.
3.2.12.B4. Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.
3.2.P.B3. Explain how energy flowing through an open system can be lost.

Big Ideas

- The laws of thermodynamics describe the essential role of energy and explain and predict the direction of matter changes.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

Essential Questions

- How do the forces of attraction between different chemicals result in mixtures with predictable properties?
- What causes chemicals to have forces of attraction that differ from those to other chemicals?

Content

- Intermolecular forces are the forces of attraction between molecules, while intramolecular forces (also known as covalent bonds) are the forces of attraction within molecules.
- Intramolecular forces determine the chemical properties of a chemical and intermolecular forces determine the physical properties of a chemical.
- There are three types of intermolecular forces: (1) London dispersion forces, (2) dipole-dipole interactions, and (3) hydrogen bonding.
- When comparing molecules of similar size those that have all hydrogen bonding (along with dipole-dipole interactions and LDF) have stronger intermolecular forces than those that have dipole-dipole interactions (along with LDF) and those that only have London dispersion forces.
- Network covalent systems are created when atoms covalently bond in an extended two or three-dimensional manner, creating what is equivalent to very large molecules.

Skills

- Evaluate chemical formulas to determine the interparticle forces present.
- Explain how intermolecular forces determine the physical properties (e.g. enthalpies of vaporization, boiling point temperatures, etc.) of a chemical.
- Compare and contrast intramolecular forces and intermolecular forces in terms of relative strength and properties.
- Draw Lewis structures for molecular compounds and determine the types of intermolecular forces (London dispersion forces, dipole-dipole interactions, and hydrogen bonding) present.
- Predict the solubility of a solute in a solvent using electrostatic forces of attraction.
- Predict the relative strengths of physical properties based on intermolecular forces.
- Explain differences in physical properties (e.g. enthalpies of fusion, melting point temperature, etc.) based on interparticle forces.

Return to Table of Contents

• A network covalent systems creates a strong, low energy system whose properties (e.g. high melting-point temperature, large hardness, lack of solubility, etc.) are an indication of the strength of the system. • Solutions are created when a solvent is capable of pulling apart solute particles due to the electrostatic attraction. • Solutions are homogeneous mixtures comprised of two or more components, one of which is referred to as the solvent. • Chemicals with similar intermolecular attractive forces tend to interact with one another to create a solution (i.e. "likes dissolve likes"). • The polarity of water makes it a great solvent for polar solutes and ionic compounds, which is why it is commonly referred to as the "universal solvent". • The creation of a solution is accompanied with a corresponding energy change (exothermic or endothermic). • The overall enthalpy change in the formation of a solution is dependent on three different molecular-level interactions (solute-solute, solvent-solvent, and solute solvent). • When the energy change is unfavorable the increase in randomness associated with dissolution becomes the driving force for the spontaneity of the process. • The total enthalpy change associated with the formation of a solution is an extensive property that depends on the amount of solute dissolved and is experimentally determined using calorimetry. • Colligative properties are properties of solutions that depend on the number of solute particles present (not the identity of the solute) and include vapor pressure depression, boiling point elevation, freezing point depression, and osmotic pressure.	• Organize chemicals in increasing or decreasing order of observed physical properties based on chemical formulas. • Draw interparticle interactions using Lewis structures and ions.

Unit #/Title	9.5/Nomenclature	Time Frame	32 Weeks

Standards	
N/A	
Big Ideas	**Essential Questions**
• Chemicals are named categorically based on the types of elements present in the chemical and the system of interactions that exist between those elements.	• How are the individual components of a chemical and the structure of a compound used in identifying the name of a chemical compound?
Content	**Skills**
• Chemical nomenclature is the system of naming chemicals following a defined set of rules. • Compounds can be broken down into categories, all of which have their own unique rules for naming chemicals. • Binary ionic compounds are named using the name of the cation and the base of the anion followed by the suffix -ide (exceptions are polyatomic ions). • Binary molecular compounds are named using a system of prefixes (exceptions are acids). • Binary acids are named using the prefix hydro-, the base of the nonhydrogen atom, and the suffix -ic, followed by acid (e.g. HCl is hydrochloric acid). • Ternary acids are named using the base of the polyatomic anion and a system of prefixes and suffixes, which indicate how many protons and oxygens are present. • Simple hydrocarbons are named based on the number of carbon atoms present in the carbon backbone.	• Identify the names of chemicals based on the elements present in the compound. • Remember the common polyatomic ions and their appropriate charges.

Unit #/Title	10/Chemical Kinetics	Time Frame	2 Weeks

Standards

3.2.10.A4. Explain the difference between endothermic and exothermic reactions. Identify the factors that affect the rates of reactions.
3.2.10.B3. Analyze the processes of convection, conduction and radiation between objects or regions that are at different temperatures.
3.1.C.A2. Describe how changes in energy affect the rate of chemical reactions.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas	Essential Questions
● Rates of chemical reactions are determined by details of the molecular collisions. ● Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them. ● Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.	● What factors determine how quickly a reaction takes place? ● How do molecular shape and motion impact the observed rates of reactions on a macroscopic level?

Content	Skills
● Chemical reactions can be explained in terms of thermodynamics and kinetics, both of which must be understood in order to accurately describe the reaction. ● In order for a chemical reaction to take place the reactant particles must collide with one another in the proper orientation and with enough energy to reach the activated state (i.e. to break old bonds). ● Only a small fraction of collisions at a given temperature are capable of reaching the activated state and this can be confirmed by applying the Arrhenius equation. ● The are four ways that scientists alter the rate of a chemical reaction: (1) change the temperature, (2) change reactant concentrations, (3) introduce a catalyst (when possible), and (4) change the surface area of solid, liquid, reactants. ● Changing temperature and adding a catalyst to a reaction change the fraction of reactant particles reaching the activated state, altering the rate of the reaction. ● Changing reactant concentrations and the surface area of solid, or liquid, reactants changes the collision frequency, altering the rate of the reaction. ● A Boltzmann distribution demonstrates the distribution of kinetic energy of matter at a given temperature and is often used to indicate the fraction of particles reaching the activated state for a reaction.	● Explain the relationships between the macroscopic changes and chemical collision on a molecular level. ● Calculate chemical reaction rates using experimental data. ● Calculate the fraction of particles reaching the activated state using the Arrhenius equation. ● Predict chemical rates based on changes in concentration, temperature, and presence of a catalyst. ● Utilize a Boltzmann distribution to explain how temperature and catalysts change the rate of a chemical reaction. ● Collect and analyze experimental data to support the postulates of collision theory.

• Catalysts are chemicals that increase the rate of a reaction by creating a new reaction pathway (or mechanism) that lowers the energy of activation and increases the fraction of particles reaching the activated state. • A catalyst enters and exits a reaction unchanged. • Homogeneous catalysts are those in the same state as the reactant particles and heterogeneous catalysts are those in a different state (typically a metal catalyzes gaseous reactions). • The rate of chemical reactions are determined experimentally and the type of data collected can vary depending on the characteristics of the reaction and the analytical equipment available.	

Unit #/Title	10.5/Reaction Prediction	Time Frame	6 Weeks

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table.
3.2.C.A2. Predict chemical formulas based on the number of valence electrons.
3.2.10.A4. Describe chemical reactions in terms of atomic arrangement and/or electron transfer.
3.2.C.A4. Predict how combinations of substances can result in physical and/or chemical changes. Interpret and apply the laws of conservation of mass, constant composition (definite proportions) and multiple proportions. Balance chemical equations by the law of conservation of mass. Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement and combustion.
3.2.12.A4. Apply oxidation/reduction principles to electrochemical reactions.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Chemical reactions are predictable.
- The chemical elements are fundamental building materials of matter and all can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
- Changes in matter involve the rearrangement and/or reorganization of atoms and/or transfer of electrons.

Essential Questions

- How do chemists use chemical formulas and conditions to predict the formulas of the chemicals produced in a chemical reaction?

Content

- The products of a chemical reaction can be predicted using the formulas of reactants and knowledge of the tendencies of chemicals to lose or gain electrons and/or rearrange.
- Predicting the products for precipitation reactions requires knowledge of general solubility rules.
- Combustion reactions change a fuel and oxygen into carbon dioxide and water.
- Synthesis reactions are chemical processes in which two or more simpler chemicals combined to form a more complex chemical.
- Decompositions occur under a variety of conditions, all of which take a more complex chemical and break it down into two or more simpler chemicals.
- Double displacement reactions occur when aqueous compounds “switch partners” (e.g. precipitation reactions and acid-base neutralizations).
- Precipitation reactions involve the mixing of two aqueous compounds to form one insoluble compound, known as the precipitate, and one soluble compound that remains in the supernatant liquid.
- Electrons are not exchanged in double displacement reactions

Skills

- Predict the products of chemical reactions; including decomposition, synthesis, combustion, acid-base neutralization, precipitation, and single replacements.
- Apply solubility rules to predict the formation of an insoluble compound (precipitate).
- Use standard reduction potentials to evaluate potential oxidation-reduction reactions.

• Single replacement reactions are those in which a pure element replaces a similar element that is part of a compound. • Single replacement reactions are also oxidation-reduction reactions, in which electrons are transferred from one element to another. • Standard reduction potentials are used to determine whether or not an oxidation-reduction is possible for a given mixture of chemicals. • The reduction of hydrogen is the standard for reduction potentials and is assigned a potential of 0. • Acid-base neutralization reactions result in the formation of a salt (often soluble) and water. • Acids donate protons to water to form hydronium ion.	

Unit #/Title	11/Electrochemistry & Thermochemistry	**Time Frame**	2 Weeks

Standards	
3.2.10.A4. Describe chemical reactions in terms of atomic arrangement and/or electron transfer. Explain the differences between endothermic and exothermic reactions. **3.2.12.A4.** Apply oxidation/reduction principles to electrochemical reactions. **3.2.10.B2**. Explain how the overall energy flow through a system remains constant. **3.2.10.B3.** Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. **3.2.C.B2**. Explore the natural tendency for systems to move in a direction of disorder or randomness (entropy). **3.2.C.B3.** Describe the law of conservation of energy. Explain the difference between an endothermic process and an exothermic process. **3.2.P.B4**. Develop qualitative and quantitative understandings of current, voltage and resistance, and the connections among them. **3.2.10.B6**. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws. **3.2.P.B3**. Explain how energy flowing through an open system can be lost.	
Big Ideas	**Essential Questions**
• The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes of matter. • Changes in matter involve the rearrangement and/or reorganization of atoms and/or transfer of electrons.	• How can electricity be used to force chemical reactions to take place? • How can chemical reactions be used to create electricity? • What conditions impact the tendency for a process to be spontaneous or not?
Content	**Skills**
• Electrochemistry is the study of the relationship between chemical reactions and electricity. • There are two different types of electrochemical cells, voltaic cells and electrolytic cells. • Electrolytic cells convert electrical energy into chemical energy by forcing a nonspontaneous chemical reaction to take place. • Voltaic cells, also known as Galvanic cells or batteries, utilize a spontaneous chemical reaction to convert chemical energy into electrical energy. • Voltage, current, and resistance are related properties that describe the tendency for electrons to move within an electrochemical system. • Current is the movement of electrons and is typically measured in amperes, A, or coulombs per second. • Voltage, or potential, represents the tendency for electrons to move from one position to another and it is measured in volts, V, or joules per coulomb. • An electrochemical cell contains two electrodes: (1) an anode where oxidation occurs and (2) a cathode where reduction occurs. • Oxidation, which is the loss of electrons, occurs prior to reduction, which is the gain of electrons. • Metallic current is the movement of electrons from the anode to the cathode. • Electrolytic current is the movement of ions -- within the electrochemical cell -- that prevent the buildup of	• Identify the uses of different types of electrochemical cells. • Produce a functional electrolytic cell using a variety of chemicals and standard reduction potentials. • Describe the energy changes involved in electrolytic and voltaic cells. • Produce a functional voltaic cell using a variety of chemicals and standard reduction potentials. • Determine the potential, or voltage, associated with an electrochemical process. • Use electrical current to calculate the number of electrons, particles, and mass changes involved in electrochemical processes. • Evaluate the spontaneity of electrochemical processes using thermodynamic properties. • Use entropy, enthalpy, and absolute temperature to evaluate the spontaneity of chemical processes.

charge at each electrode and allow for the reaction to continue. ● A salt bridge connects the half-cells of a voltaic cell, providing the pathway for the electrolytic current. ● Standard reduction potentials are used to predict the voltage and spontaneity of an electrochemical cell. ● Thermodynamic properties (enthalpy change and entropy change) determine whether or not a process is spontaneous or not. ● The change in free energy is an indication of whether or not a process is spontaneous and sometimes dependent on absolute temperature.	

Unit #/Title	12/Acids and Bases	Time Frame	3 Weeks

Stage 1 - Identify Desired Results

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table.
3.2.C.A1. Use electronegativity to explain the difference between polar and non-polar covalent bonds.
3.2.10.A4. Describe chemical reactions in terms of atomic arrangement and/or electron transfer.
3.2.C.A4. Predict how combinations of substances can result in physical and/or chemical changes.
3.2.12.A4. Describe the interactions between acids and bases.
3.2.12.A5. Predict the shift in equilibrium when a system is subjected to a stress.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Chemical reactions are predictable.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
- Changes in matter involve the rearrangement and/or reorganization of atoms and/or transfer of electrons.

Essential Questions

- What are the structural characteristics of chemicals present in acids and bases?
- How do acids and bases interact with their surroundings?

Content

- Acids and bases are special categories of chemicals that play vital roles in biological and commercial processes.
- All closed systems eventually establish chemical equilibrium, a condition when the rate of the forward reaction is equivalent to the rate of the reverse reaction.
- On a macroscopic-level an equilibrium appears as though nothing is happening; however, it appears this way because two opposing processes are occurring at exactly the same rate.
- Pure water is under a constant equilibrium in which two water molecules are reacting with one another to create hydronium and hydroxide ions.
- Acids and bases alter the equilibrium condition of pure water.
- In the Arrhenius model acids are considered to be any chemical that increases the hydronium ion concentration in a solution and a base is any chemical that increases the hydroxide ion concentration in a solution.
- In the Bronsted-Lowry model acids are considered to be proton donators and bases are considered to be proton acceptors.
- Acids vary in strength and there are only seven common strong acids that completely dissociate in water.

Skills

- Define acids and bases in terms of a chemical's ability to increase the hydronium or hydroxide concentrations and ability to donate or accept protons.
- Explain the acidic behavior of molecules based on the understanding of covalent bonds.
- Explain the basic behavior of metal hydroxides based on the understanding of ionic bonds.
- Calculate the concentrations of hydroxide and hydronium ions in an aqueous solution and the pH, or pOH, indicative of those concentrations.
- Determine whether a solution is acidic or basic based on ion concentrations and pH, or pOH.
- Explain the differences between strong acids and strong bases.
- Standardize a strong base and use the solution to determine the unknown concentration -- of an acidic solution -- using an acid-base titration.

• Bases vary in strength and the common strong bases are the soluble hydroxides formed by Alkali Metals and some of the Alkaline Earth Metals. • Titration is a process by which a solution of unknown concentration is evaluated using a solution of known concentration (standard). • Standardization is the process of creating a standard by titrating it against a pure substance or a standard solution. • Titrations can be monitored using either an acid-base indicator or changes in pH. • Equivalence point represents the moment in a titration when there are stoichiometrically equivalent amounts of acid and base present in solution. • Endpoint describes the moment when an observable color change has occurred due to the presence of an acid-base indicator. • Acid-base indicators are chemicals that are themselves weak acids/bases that change the color of a solution depending on whether or not the solution is acidic or basic.	

Unit #/Title	12.5/Stoichiometry	**Time Frame**	4-5 Weeks

Standards

3.2.C.A2. Use the mole concept to determine the number of particles and molar mass for elements and compounds.
3.2.10.A4. Describe chemical reactions in terms of atomic arrangement and/or electron transfer. Predict the amounts of products and reactants in a chemical reaction using mole relationships.
3.2.C.A4. Interpret and apply the laws of conservation of mass, constant composition (definite proportions) and multiple proportions. Balance chemical equations by the law of conservation of mass.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas	**Essential Questions**
• Stoichiometry is the algebraic technique that allows chemists to make quantitative predictions and evaluations of chemical reactions.	• How do chemists know how much of a chemical they need to produce a given amount of product or how how much of a product can be produced from a given amount of reactant(s)?

Content	**Skills**
• Stoichiometry is a mathematical process in which chemists use balanced chemical reactions to determined the amounts of reactants used or products produced from a known amount of chemical. • The mole-to-mole ratio is a conversion factor within a balanced chemical reaction. • A mole-to-mole ratio can be created between any two reactants, any two products, or any reactant-product combination.	• Apply the law of conservation of mass to balance chemical equations. • Use stoichiometry to calculate a variety of chemical properties (moles, mass, volumes) and make predictions about the amounts of reactants and products involved in a chemical process.

Unit #/Title	13/Nuclear Chemistry	Time Frame	2-3 Weeks

Standards

3.2.10.A1. Predict properties of elements using trends of the periodic table.
3.2.12.A2. Distinguish among the isotopic forms of elements. Explain the probabilistic nature of radioactive decay based on subatomic rearrangement in the atomic nucleus.
3.2.C.A3. Identify the three main types of radioactive decay and compare their properties. Describe the process of radioactive decay by using nuclear equations and explain the concept of half-life for an isotope. Compare and contrast nuclear fission and fusion.
3.2.12.A3. Explain how matter is transformed into energy in nuclear reactions according to the equation $E = mc^2$.
3.2.C.A4. Interpret and apply the laws of conservation of mass, constant composition (definite proportions) and multiple proportions. Balance chemical equations by the law of conservation of mass.
3.2.10.B5. Understand that waves transfer energy without transferring matter.
3.2.10.B6. Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.

Big Ideas

- Not all chemical reactions involve the movement of electrons or the reorganization of atoms/ions.
- Nuclear reactions involve the changing of subatomic particles in the nucleus, creating atoms of differing elements as a result.
- Nuclear reactions are accompanied by extremely large energy changes.

Essential Questions

- How do nuclear reactions differ from those involving the movement of electrons and reorganization of atoms/ions?
- What are the unique features of nuclear reactions that explain their uses in applications involving extremely large energy changes?

Content

- Nuclear reactions involve the changing of the nucleus of an atom, not only the transfer of electrons.
- Nuclear decay is due to the instability of the nucleus caused by the presence of a large number of protons and their electrostatic repulsion of one another.
- Neutrons are the glue that hold the positively charged protons together in the nucleus and as the number of protons in the nucleus increases so does the ratio of neutrons to protons.
- All atoms that with atomic numbers above 82 have radioactive nuclei.
- The three most common types of radiation emitted by unstable nuclei are alpha particles, beta particles, and gamma radiation.
- The relative danger of radiation is dependent on the emitted particle’s ability to penetrate matter (penetrating power).
- Additional radioactive processes include positron emission, the release of a positively charged particle with the mass of an electron that converts a proton to a neutron, and electron capture, the gaining of an electron by the nucleus which also changes a proton to a neutron.
- Radioactive decay rates are typically expressed in half-lives, or the time it takes for one half of the material present to decay.

Skills

- Write balanced reactions for the radioactive decay of atoms.
- Explain the stability of nuclei in terms of the numbers of protons and neutrons present.
- Compare the energy changes of regular chemical reactions, in which electrons are exchanged or atoms are rearranged, and nuclear reactions, in which the nuclei are changing.
- Calculate the energy change associated with the mass changes resulting from a chemical change.
- Compare and contrast nuclear fission and fusion.

• The radioactive decay of carbon-14 in lifeless material can be used to estimate age. • Nuclear reactions are accompanied by the release of a large amount of energy magnitudes higher than the energy released in a typical chemical reaction. • Fusion is the process of combining light nuclei to create a heavier, more stable nucleus. • Fission is the splitting of heavier nuclei into lighter, more stable nuclei. • The energy change associated with a reaction is directly proportional to the product of the change in mass and the square of the speed of light, as explained by Einstein's theory of relativity. • The mass of a nucleus is always smaller than the sum of the masses of the subatomic particles that comprise it, a fact known as the mass defect. • The critical mass is the mass of a radioactive material necessary to sustain a chain reaction.	