Unit 1: Measurement and Matter

Learning Outcomes The student will be able to:	Standards
• Determine conversion factors necessary to convert between units. • Identify and plot variables. • Use dimensional analysis to solve multi-step problems. • Apply proper SI units in measurements, • Calculate and solve problems using English and SI units. • Calculate and compare the densities of solids, liquids, and gases. • Graph experimental data, calculate slope, interpolate, and extrapolate to identify unknown variables. • Determine percent error and assess accuracy and precision of measurement. • Analyze physical properties to characterize matter. • Differentiate between elements, compounds, mixtures, and solutions. • Analyze properties of matter and mixtures in order to determine the separation technique(s) necessary to separate a mixture. • Perform calculations using significant figures.	• Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. • Select appropriate tools to collect, record, analyze, and evaluate data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply techniques of algebra and functions to represent and solve scientific problems. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Unit 2: Matter and Reactions

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<tr><th>Learning Outcomes
The student will be able to:</th><th>Standards</th></tr>
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Formulas & Nomenclature

Understand formula represents quantity and type of atoms present
Differentiate between ionic compounds and molecular compounds
Write names and formulas for:

binary ionic compounds
binary molecular compounds
ternary compounds (given polyatomic ions and their respective charges)
compounds involving transition metals (given charges)
acids (including oxyacids)

The Mole

Understand the basis for atomic masses of elements is carbon
Understand the mole is a unit to quantify larger numbers
Differentiate between various units that can represent the same quantity
Calculate the relationship between quantity and type of atoms present and their percentages within a compound
Determine the molar mass of a molecule from its formula and the Periodic Table
Calculate the percentage composition of various compounds including hydrates can be calculated using formula and molar mass values.
Understand how calculations are performed using Avogadro's number: $6.02x10^{23}$ (number of particles per mole).
Analyze a problem to determine the calculations that need to be performed to convert amongst grams-moles-molecules.
Utilize the molarity of a solution as a measure of concentration and determined quantitatively that concentration.
Prepare solutions of specific molar concentrations in the lab
Differentiate between empirical and molecular formulas and analyze empirical data to determine these formulas.
Analyze real world date to determine the % by mass of an element in an ore or other sample can be determined quantitatively

Reactions

Identify the evidence that verifies that matter can undergo chemical changes.
Understand and prove that matter is conserved in chemical reactions.
Understand the difference between reactants and products of a chemical reaction.
Identify the seven common diatomic molecules
Analyze a set of reactants to determine if a combination of matter produces a chemical reaction or if there would be no reaction.
Complete, write and balance chemical equations that represent the following reaction types:

Main group elements

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PS1.B: Chemical Reactions: The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (HS-PS1-2)
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (HS-PS1-7)

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- Combustion - Synthesis (simple) - Decomposition (simple) - carbonates, bicarbonates - Single Replacement - Double Displacement - Acidic Anhydride - How chemists utilize the Activity Series to determine if a reaction occurs. - How chemists utilize a solubility chart to determine if a reaction occurs. Stoichiometry - Understand the coefficients of balanced equations represent mole ratios - Analyze experimental data given an amount of one reactant or product, determine the amount of any other reactant or product. - Analyze a reaction quantitatively to be able to convert amongst amount of reactants and products using balanced chemical equations - Mole-mole - Mass-mass - Molarity-mass - Given amounts of all reactants, determine the one reactant will be completely consumed and limit the amount of product that can be formed while determining the amount of the excess reactant that is consumed - Analyze a set of data and to mathematically determine the limiting and excess reactant. - Using the limiting reactant, calculate the excess reactant, amount of excess reactant, and theoretical yield based on excess reactant. - Differentiate between theoretical and experimental yields - Analyze a reaction to determine the percentage yield. - Calculate and apply percentage error of theoretical vs. experimental yields.	

Unit 3: Atomic Theory, Structure, and Trends

Learning Outcomes The student will be able to:	Standards

• Evaluate the model of the atom and include contributions and shortcomings of several theorists.
• Know the three subatomic particles and their functions in an atom
• Understand the current model of the atom, the Quantum Mechanical Model
• Evaluate an atom in terms of energy levels, sublevels, orbital, and spin (quantum numbers)
• Apply the Pauli Exclusion Principle to atoms
• Explain the relationship between speed of light, frequency, and wavelength
• Explain the duality of light
• Evaluate the energy of photons and their relationship to frequency and wavelength
• Explain how the periodic table is structured into periods and groups according the properties of the elements
• Explain the relationships presented in Coulomb's Law
• Utilize the Shielding Effect to explain atomic properties.
• Calculate half life and understand that Half-life can be used to determine the age of materials
• Calculate the average atomic mass of isotopes
• Explain Neils Bohr's contribution to the view of the atom
• Differentiate between an atom in the ground state vs. an atom in the excited state
• Relate the color of a flame to ground state and excited states
• Understand the relationship of the various forms of electromagnetic radiation.
• Explain the energy relationships of the transition of an electron between energy levels
• Write equations to show how alpha and beta particles as well as positrons and k-electron capture can be used to represent nuclear reactions
• Explain the difference between fission and fusion in terms of both particle arrangement and energy.
• Understand that, and write/model, electron configurations and orbital filling diagrams can be used to model electron arrangement for
    ○ Main group elements
    ○ Transition metals
    ○ Ions
    ○ Isoelectronic species
• Explain the relationship between the position of an element on the periodic table and its atomic number, electron configuration, and physical and chemical properties
• Know how the periodic table is used to identify metals, nonmetals, and metalloids.
• Know the difference between periods and families of the periodic table how to classify elements according
	• Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. **(HS-PS1-8)**
	• Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. **(HS-PS4-3)**
	• Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. **(HS-PS4-4)**
	• Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons the outermost energy level of atoms. **(HS-PS1-1)**
	• **Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. (HS-ESS1-1)**
	• **Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the Universe. (HS-ESS1-2)**
	• **Communicate scientific ideas about the way stars, over their life cycle, produce elements. (HS-ESS1-3)**

to families. ● Explain the relationship between size, effective nuclear charge, and Coulombic Attraction of atoms ● Explain and Identify trends in ionization energy, atomic and ionic radius, electronegativity, and electron affinity using the periodic table. ● Analyze the differences in sizes between metal atoms and their cations and nonmetal atoms and their anions.	

Unit 4: Bonding and Intermolecular Forces

Learning Outcomes The student will be able to:	Standards
• Know that atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds • Understand how ionization energy and electronegativity are related to bond formation • Know that molecules that share electrons can do so equally or unequally • Differentiate between ionic, covalent, and metallic bonding and network covalent structures • Utilize energy diagrams as they relate to bond length and bond strength • Understand ionic compounds form crystal lattice structures • Recognize that salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction • Draw Lewis dot structures to provide models of atoms and molecules • Understand that molecules that share electrons can do so equally or unequally • Understand that molecules have characteristic shapes depending on their bonding and non-bonding electron pairs • Predict the shape of molecules and their polarity from Lewis dot structures and VSEPR. • Understand the polar nature of water molecule due to its molecular structure • Predict and model expanded octets. • Determine the hybridization of molecules sigma and of pi bonds • Explain resonance through the delocalization of electrons • Classify chemical bonds between atoms in molecules such as H_2, CH_4, NH_3, H_2CCH_2, N_2, Cl_2, and many large biological molecules as covalent. • Explain the differences between intermolecular and intramolecular forces • Understand that molecules are held together by weaker intermolecular forces • Differentiate amongst dispersion forces, dipole forces, hydrogen bonding • Explain that the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form • Understand how the properties of liquids and solids are related to their intermolecular forces • Explain the differences in boiling points due to polarizability of molecules • Explain how the bonding and intermolecular forces of materials impact their functionality and purpose. • Explain the relationship between measurable properties of a substance and the strength of the electrical forces between the particles of the substance. (e.g. melting point, boiling point, vapor pressure, surface tension). • Explain the thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles together.	• Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (HS-PS1-2) • Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (HS-PS1-3) • Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (HS-PS2-6)

Unit 5: Thermochemistry

Learning Outcomes **The student will be able to:**	**Standards**
• Differentiate between kinetic and potential energy. • Understand that matter can undergo physical changes • Identify the changes in energy accompany physical and chemical changes. • Calculate heat of chemical and physical processes.. • Explain the different types of energy involved in phase changes of a substance. • Use specific heat, mass, and temperature to calculate the energy into and out of a substance. • Apply calorimetry to evaluate heat transfer between system and surroundings. • Write and utilize mathematical models to calculate the heat involved in a phase change using specific heats and calorimetry. (stress the KE/PE connection) • Use Hess's Law to calculate enthalpy change in a reaction • Use Hess's Law to calculate enthalpy change in a reaction by "products – reactants" and by manipulating equations • Explain how heat of formation is related to heat of reaction. • Explain the differences qualitatively and quantitatively between exothermic and endothermic reactions. • Explain that the heat that accompanies a chemical reaction is stoichiometrically related to reactants and products. • Identify and interpret information on a potential energy diagram in terms of reactant and product bond energy.	• Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. **(HS-PS1-4)** • Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). **(HS-PS3-4)** • Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. **(HS-ESS2-4)**

Unit 6: Kinetics and Equilibrium

Learning Outcomes The student will be able to:	Standards
• Explain how an effective collision must occur in order for a reaction to happen. • Understand that reaction can occur both in the forward and reverse directions. • Write an equilibrium constant expression. • Explain how factors influence the state of equilibrium of a system. • Relate the solubility of salts to their equilibria. • Explain how concentration, pressure, catalysts, and temperature impact the rate of reaction, specifically in terms of effective collisions. • Explain that an effective collision is one in which reacting particles collide at the correct orientation and with sufficient energy to break old bonds and form new bonds. • Understand that an increase in temperature increases the kinetic energy, giving the molecules enough energy to break the old bonds and form the new bonds. • Know that a system in equilibrium is related to the rates of the forward and reverse reactions. • Explain how an equilibrium constant can be used to determine the extent of a reaction. • Explain that the reaction quotient is the ratio of concentrations of products to reactants; if the rates of the forward and reverse reactions are equal, the reaction quotient is given the name “equilibrium constant”. • Calculate the numerical value of the equilibrium constant using the equilibrium concentrations of reactants and products. • Understand that a large equilibrium constant implies products are favored, a small equilibrium constant implies reactants are favored. • Explain how changes in temperature, pressure, common ions, and concentration can be used in conjunction with the tenets of LeChatelier’s Principle to produce shifts in equilibrium. • Apply “Ice boxes” to determine the equilibrium concentration of reaction constituents as well as the value of the equilibrium constant. • Analyze solid/aqueous equilibrium to determine the Ksp of a saturated solution, and from a Ksp value, the solubility of a salt can be calculated.	• Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. **HS-PS1-5** • Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. **HS-PS1-6**

Unit if Time: Acids & Bases

Learning Outcomes The student will be able to:	Standards
• Know the pH scale is a measure of the hydrogen ion concentration of a solution. • Understand that indicators change color at different pH levels. • Explain how acids and bases can react with each other and can be evaluated quantitatively and qualitatively. • Know the strong acids and bases. • Understand that weak acids and bases differ from strong acids and bases in terms of percentage ionization. • Predict how salts can be acidic, basic, or neutral. • Know that titration is process that is used to determine the concentration of an acid or base. • Explain how carbon dioxide reacts with water to form acids. • Differentiate between acids and bases according to the Arrhenius and Bronsted-Lowry theories. • Explain the use of the indicators phenolphthalein and litmus paper in identifying acids and bases. • Calculate pH, pOH, [H+] and [OH-] for strong and weak acids and bases. • Calculate Ka and Kb for weak acids and bases. • Calculate the percent ionization of a weak acid or base. • Perform acid-base titrations and analyze data to determine molarity of unknown. • Write hydrolysis reactions for salts. • Describe and identify neutralization reactions including acids with carbonates and bicarbonates. • Understand the role Kw plays in acid/base theory.	Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Unit if Time: Gases

Learning Outcomes The student will be able to:	Standards
● Explain ow gas molecules move according to the Kinetic Molecular Theory of Gases. ● Identify properties unique to gasses. ● Apply gas measurement units. ● Understand the difference between barometers and manometers as well as the different pressure units. ● Use Molar volume in calculations involving gases. ● Understand the significance of absolute zero and the Absolute Temperature Scale. ● Explain the behaviors of ideal vs. real gases. ● Utilize standard temperature and pressure in gas law problems. ● Calculate gas parameters using Boyle's, Charles', the Combined Gas Law, and the Ideal Gas Law. ● Analyze reactions involving gases and solids and/or liquids stoichiometrically ● Utilize the Ideal Gas Law to determine the molar mass and density of a gas.	● Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims. ● Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. ○ Apply techniques of algebra and functions to represent and solve scientific problems. ○ Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. ○ Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Unit if Time: Solutions

Learning Outcomes The student will be able to:	Standards
• **Understand ionization and dissociation occur to solids in aqueous solution.** • **Explain "Like Dissolves Like" in terms of solutes and solvents** • **Determine and explain how several factors influence the rate of solvation** • **Understand the nature of the solute can impact the magnitude of the change in freezing and boiling points** • **Utilize the concentration of an aqueous solution to determine the qualitative and quantitative impacts on the freezing and boiling points of the solution** • **Calculate molality as another unit of solutions concentration** • **Calculate the molality of a solution and use it to determine the freezing and boiling points of solution**	• Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. ○ Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ○ Apply techniques of algebra and functions to represent and solve scientific and engineering problems. ○ Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Unit 8: Chemistry and the Earth (might be moved to other courses)

Learning Outcomes The student will be able to:	Standards
• Know that the Earth systems include the hydrosphere, geosphere, atmosphere, and biosphere. • Know the hydrosphere involves any water on Earth. • Know the geosphere involves the non-water Earth surfaces and subsurface structures. • Know the atmosphere includes all the gases above the surface of the Earth. • Know the biosphere includes all living things. • Explain how feedback between Earth systems can be positive or negative. • Explain the cause/effect relationship between human activity and Earth systems. • Analyze geoscience data to allow for understanding and prediction of Earth cycles. • Explain how wobble, tilt, and eccentricity impact the energy and climate on Earth.	**HS-ESS2-2.** Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to Earth's systems. **HS-ESS2-4**. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. **HS-ESS2-6.** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. **HS-ESS3-5.** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. **HS-ESS3-1**. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.