1. Atomic Concepts	
Major Understandings	Skills, students should be able to:
The modern model of the atom has evolved over a long period of time through the work of many scientists.	The student should be able to: relate experimental evidence to models of the atom
Each atom has a nucleus, with an overall positive charge, surrounded by negatively charged electrons.	use models to describe the structure of an atom
Subatomic particles contained in the nucleus include protons and neutrons.	
The proton is positively charged, and the neutron has no charge. The electron is negatively charged.	
Protons and electrons have equal but opposite charges. The number of protons is equal to the number of electrons in an atom.	determine the number of protons or electrons in an atom or ion when given one of these values
The mass of each proton and each neutron is approximately equal to one atomic mass unit. An electron is much less massive than a proton or neutron.	calculate the mass of an atom, the number of neutrons or the number of protons, given the other two valu
In the wave-mechanical model (electron cloud), the electrons are in orbitals, which are defined as regions of most probable electron location (ground state).	
Each electron in an atom has its own distinct amount of energy.	
When an electron in an atom gains a specific amount of energy, the electron is at a higher energy state (excited state).	distinguish between ground state and excited state electron configurations, e.g., 2-8-2 vs. 2- 7-3
When an electron returns from a higher energy state to a lower energy state, a specific amount of energy is emitted. This emitted energy can be used to identify an element.	identify an element by comparing its bright-line spectrum to given spectra
The outermost electrons in an atom are called the valence electrons. In general, the number of valence electrons affects the chemical properties of an element.	draw a Lewis electron-dot structure of an atom distinguish between valence and non-valence electrons, given an electron configuration, e.g., 2-8-2
Atoms of an element that contain the same number of protons but a different number of neutrons are called isotopes of that element.	
The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes.	given an atomic mass, determine the most abundant isotope, calculate the atomic mass of an element, given the masses and ratios of naturally occurring isotopes.

2. Periodic Table	
Major Understandings	Skills, students should be able to:
The placement or location of an element on the Periodic Table gives an indication of physical and chemical properties of that element. The elements on the Periodic Table are arranged in order of increasing atomic number.	explain the placement of an unknown element in the Periodic Table based on its properties
The number of protons in an atom (atomic number) identifies the element. The sum of the protons and neutrons in an atom (mass number) identifies an isotope. Common notations that represent isotopes include: ^{14}C, carbon-14, C-14.	interpret and write isotopic notation
Elements can be classified by their properties, and located on t he Periodic Table, as metals, nonmetals, metalloids (B, Si, Ge, As, Sb, Te) , and noble gases.	classify elements as metals, nonmetals, metalloids, or noble gases by their properties
Elements can be differentiated by their physical properties. Physical properties of substances, such as density, conductivity, malleability, solubility, and hardness, differ among elements.	describe the states of the elements at STP
Elements can be differentiated by chemical properties. Chemical properties describe how an element behaves during a chemical reaction.	
Some elements exist as two or more forms in the same phase. These forms differ in their molecular or crystal structure, and hence in their properties.	
For Groups 1, 2, and 13-18 on the Periodic Table, elements within the same group have the same number of valence electrons (helium is an exception) and therefore similar chemical properties.	determine the group of an element, given the chemical formula of a compound, e.g., XCl or XCl_2
The succession of elements within the same group demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties.	compare and contrast properties of elements within a group or a period for Groups 1, 2, 13- 18 on the Periodic Table
The succession of elements across the same period demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties	

3. Moles & Stoichiometry	
Major Understandings	Skills, students should be able to:
A compound is a substance composed of two or more different elements that are chemically combined in a fixed proportion. A chemical compound can be broken down by chemical means. A chemical compound can be represented by a specific chemical formula and assigned a name based on the IUPAC system.	
Types of chemical formulas include: empirical, molecular, and structural.	
The empirical formula of a compound is the simplest whole number ratio of atoms of the elements in a compound. It may be different from the molecular formula, which is the actual ratio of atoms in a molecule of that compound.	determine the molecular formula, given the empirical formula and molecular mass determine the empirical formula from a molecular formula
In all chemical reactions there is a conservation of mass, energy, and charge.	interpret balanced chemical equations in terms of conservation of matter and energy
A balanced chemical equation represents conservation of atoms. The coefficients in a balanced chemical equation can be used to determine mole ratios in the reaction.	balance equations, given the formulas for reactants and products. interpret balanced chemical equations in terms of conservation of matter and energy create and use models of particles to demonstrate balanced equations calculate simple mole-mole stoichiometry problems, given a balanced equation
The formula mass of a substance is the sum of the atomic masses of its atoms. The molar mass (gram formula mass) of a substance equals one mole of that substance.	calculate the formula mass and the gram-formula mass
The percent composition by mass of each element in a compound can be calculated mathematically.	determine the number of moles of a substance, given its mass determine the mass of a given number of moles of a substance
Types of chemical reactions include synthesis, decomposition, single replacement, and double replacement.	identify types of chemical reactions

4. Chemical Bonding	
Major Understandings	Skills, students should be able to:
Compounds can be differentiated by their chemical and physical properties.	distinguish among ionic, molecular, and metallic substances, given their properties
Two major categories of compounds are ionic and molecular (covalent) compounds.	
Chemical bonds are formed when valence electrons are: transferred from one atom to another (ionic); shared between atoms (covalent); mobile within a metal (metallic).	demonstrate bonding concepts using Lewis dot structures representing valence electrons: transferred (ionic bonding); shared (covalent bonding); in a stable octet
In a multiple covalent bond, more than one pair of electrons are shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond.	
Molecular polarity can be determined by the shape and distribution of the charge. Symmetrical (nonpolar) molecules include CO2, CH4, and diatomic elements. Asymmetrical (polar) molecules include HCl, NH_3, H_2O.	
When an atom gains one or more electrons, it becomes a negative ion and its radius increases. When an atom loses one or more electrons, it becomes a positive ion and its radius decreases.	
When a bond is broken, energy is absorbed. When a bond is formed, energy is released.	
Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases have stable valence electron configurations and tend not to bond.	determine the noble gas configuration an atom will achieve when bonding
Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.	
Electron-dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions.	demonstrate bonding concepts, using Lewis dot structures representing valence electrons: transferred (ionic bonding); shared (covalent bonding); in a stable octet
Electronegativity indicates how strongly an atom of an element attracts electrons in a chemical bond. Electronegativity values are assigned according to arbitrary scales.	
The electronegativity difference between two bonded atoms is used to assess the degree of polarity in the bond.	distinguish between nonpolar covalent bonds (two of the same nonmetals) and polar covalent bonds
Metals tend to react with nonmetals to form ionic compounds. Nonmetals tend to react with other nonmetals to form molecular (covalent) compounds. Ionic compounds containing polyatomic ions have both ionic and covalent bonding.	

5. Physical Behavior of Matter	
Major Understandings	Skills, students should be able to:
Matter is classified as a pure substance or as a mixture of substances.	
The three phases of matter (solids, liquids, and gases) have different properties	use a simple particle model to differentiate among properties of a solid, a liquid, and a gas
A pure substance (element or compound) has a constant composition and constant properties throughout a given sample, and from sample to sample.	use particle models/diagrams to differentiate among elements, compounds, and mixtures
Elements are substances that are composed of atoms that have the same atomic number. Elements cannot be broken down by chemical change.	
Mixtures are composed of two or more different substances that can be separated by physical means. When different substances are mixed together, a homogeneous or heterogeneous mixture is formed.	
The proportions of components in a mixture can be varied. Each component in a mixture retains its original properties.	
Differences in properties such as density, particle size, molecular polarity, boiling point and freezing point, and solubility permit physical separation of the components of the mixture.	describe the process and use of filtration, distillation, and chromatography in the separation of a mixture
A solution is a homogeneous mixture of a solute dissolved in a solvent. The solubility of a solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and solvent.	interpret and construct solubility curves use solubility curves to distinguish among saturated, supersaturated and unsaturated solutions apply the adage "like dissolves like" to the real-world
The concentration of a solution may be expressed as: molarity (M), percent by volume, percent by mass, or parts per million (ppm).	describe the preparation of a solution, given the molarity interpret solution concentration data calculate solution concentrations in molarity (M), percent mass, and parts per million (ppm)
The addition of a nonvolatile solute to a solvent causes the boiling point of the solvent to increase and the freezing point of the solvent to decrease. The greater the concentration of solute particles the greater the effect.	

5. Physical Behavior of Matter	
Major Understandings	Skills, students should be able to:
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Energy can exist in different forms, such as chemical, electrical, electromagnetic, thermal, mechanical, + nuclear	
Heat is a transfer of energy (usually thermal energy) from a body of higher temperature to a body of lower temperature. Thermal energy is associated with the random motion of atoms and molecules.	distinguish between heat energy and temperature in terms of molecular motion and amount of matter qualitatively interpret heating and cooling curves in terms of changes in kinetic and potential energy, heat of vaporization, heat of fusion, and phase changes
Temperature is a measure of the average kinetic energy of the particles in a sample of matter. Temperature is not a form of energy.	distinguish between heat energy and temperature in terms of molecular motion and amount of matter explain phase changes in terms of the changes in energy and intermolecular distance
The concept of an ideal gas is a model to explain behavior of gases. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature.	
Kinetic molecular theory (KMT) for an ideal gas states all gas particles: ⊙ are in random, constant, straight-line motion ⊙ are separated by great distances relative to their size; ⊙ the volume of gas particles is considered negligible ⊙ have no attractive forces between them ⊙ have collisions that may result in a transfer of energy between particles, but the total energy of the system remains constant.	
Collision theory states that a reaction is most likely to occur if reactant particles collide with the proper energy and orientation	
Kinetic molecular theory describes the relationships of pressure, volume, temperature, velocity, and frequency and force of collisions among gas molecules.	explain the gas laws in terms of KMT solve problems, using the combined gas law

5. Physical Behavior of Matter	
Major Understandings	Skills, students should be able to:
Equal volumes of gases at the same temperature and pressure contain an equal number of particles.	convert temperatures in Celsius degrees (°C) to kelvins (K), and kelvins to Celsius degrees
The concepts of kinetic and potential energy can be used to explain physical processes that include: fusion (melting); solidification (freezing); vaporization (boiling, evaporation), condensation, sublimation, and deposition.	qualitatively interpret heating and cooling curves in terms of changes in kinetic and potential energy, heat of vaporization, heat of fusion, and phase changes calculate the heat involved in a phase or temperature change for a given sample of matter explain phase change in terms of the changes in energy and intermolecular distances
A physical change results in the rearrangement of existing particles in a substance. A chemical change results in the formation of different substances with changed properties	
Chemical and physical changes can be exothermic or endothermic.	distinguish between endothermic and exothermic reactions, using energy terms in a reaction equation, "H, potential energy diagrams or experimental data
The structure and arrangement of particles and their interactions determine the physical state of a substance at a given temperature and pressure.	use a simple particle model to differentiate among properties of solids, liquids, and gases
Intermolecular forces created by the unequal distribution of charge result in varying degrees of attraction between molecules. Hydrogen bonding is an example of a strong intermolecular force.	explain vapor pressure, evaporation rate, and phase changes in terms of intermolecular forces
Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.	compare the physical properties of substances based upon chemical bonds and intermolecular forces

6. Kinetics and Equilibrium

Major Understandings	Skills, students should be able to:
Collision theory states that a reaction is most likely to occur if reactant particles collide with the proper energy and orientation.	use collision theory to explain how various factors, such as temperature, surface area, and concentration, influence the rate of reaction
The rate of a chemical reaction depends on several factors: temperature, concentration, nature of reactants, surface area, and the presence of a catalyst.	
Some chemical and physical changes can reach equilibrium.	identify examples of physical equilibria as solution equilibrium and phase equilibrium, including the concept that a saturated solution is at equilibrium
At equilibrium the rate of the forward reaction equals the rate of the reverse reaction. The measurable quantities of reactants and products remain constant at equilibrium.	describe the concentration of particles and rates of opposing reactions in an equilibrium system
LeChatelier's principle can be used to predict the effect of stress (change in pressure, volume, concentration, and temperature) on a system at equilibrium.	qualitatively describe the effect of stress on equilibrium, using LeChatelier's principle
Energy released or absorbed by a chemical reaction can be represented by a potential energy diagram.	read and interpret potential energy diagrams: PE of reactants and products, activation energy (with or without a catalyst), heat of reaction
Energy released or absorbed by a chemical reaction (heat of reaction) is equal to the difference between the potential energy of the products and the potential energy of the reactants.	
A catalyst provides an alternate reaction pathway which has a lower activation energy than an uncatalyzed reaction.	
Entropy is a measure of the randomness or disorder of a system. A system with greater disorder has greater entropy.	compare the entropy of phases of matter
Systems in nature tend to undergo changes toward lower energy and higher entropy	

7. Organic Chemistry	
Major Understandings	Skills, students should be able to:
Organic compounds contain carbon atoms which bond to one another in chains, rings, and networks to form a variety of structures. Organic compounds can be named using the IUPAC system.	classify an organic compound based on its structural or condensed structural formula
Hydrocarbons are compounds that contain only carbon and hydrogen. Saturated hydrocarbons contain only single carbon-carbon bonds. Unsaturated hydrocarbons contain at least one multiple carbon-carbon bond.	draw structural formulas for alkanes, alkenes, and alkynes containing a maximum of ten carbon atoms
Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are types of organic compounds that differ in their structures. Functional groups impart distinctive physical and chemical properties to organic compounds.	classify an organic compound based on its structural or condensed structural formula draw a structural formula with the functional group(s) on a straight chain hydrocarbon backbone, when given the correct IUPAC name for the compound
Isomers of organic compounds have the same molecular formula, but different structures and properties.	
In a multiple covalent bond, more than one pair of electrons are shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond.	
Types of organic reactions include: addition, substitution, polymerization, esterification, fermentation, saponification, and combustion.	identify types of organic reactions determine a missing reactant or product in a balanced equation

8. Oxidation and Reduction	
Major Understandings	Skills, students should be able to:
An oxidation-reduction (redox) reaction involves transfer of electrons (e^-).	determine a missing reactant or product in a balanced equation
Reduction is the gain of electrons.	
A half-reaction can be written to represent reduction.	write and balance half-reactions for oxidation and reduction of free elements and their monatomic ions
Oxidation is the loss of electrons.	
A half-reaction can be written to represent oxidation.	
In a redox reaction the number of electrons lost is equal to the number of electrons gained.	
Oxidation numbers (states) can be assigned to atoms and ions. Changes in oxidation numbers indicate that oxidation and reduction have occurred.	
An electrochemical cell can be either voltaic or electrolytic. In an electrochemical cell, oxidation occurs at the anode and reduction at the cathode.	compare and contrast voltaic and electrolytic cells
A voltaic cell spontaneously converts chemical energy to electrical energy	identify and label the parts of a voltaic cell (cathode, anode, salt bridge) and direction of electron flow, given the reaction equation use an activity series to determine whether a redox reaction is spontaneous
An electrolytic cell requires electrical energy to produce chemical change. This process is known as electrolysis.	identify and label the parts of an electrolytic cell (anode, cathode) and direction of electron flow, given the reaction equation

9. Acids and Bases	
Major Understandings	Skills, students should be able to:
Behavior of many acids and bases can be explained by the Arrhenius theory. Arrhenius acids and bases are electrolytes.	given properties, identify substances as Arrhenius acids or Arrhenius bases
An electrolyte is a substance which, when dissolved in water, forms a solution capable of conducting an electr ic current. The ability of a solution to conduct an electric current depends on the concentration of ions.	
Arrhenius acids yield $H^+_{(AQ)}$ hydrogen ion as the only positive ion in aqueous solution. The hydrogen ion may also be written as $H_3O^+_{(AQ)}$, hydronium ion.	
Arrhenius bases yield $OH^-_{(AQ)}$ hydroxide ion as the only negative ion in an aqueous solution.	
In the process of neutralization, an Arrhenius acid and an Arrhenius base react to form salt and water.	write simple neutralization reactions when given the reactants
Titration is a laboratory process in which a volume of solution of known concentration is used to determine the concentration of another solution.	calculate the concentration or volume of a solution, using titration data
There are alternate acid-base theories. One such theory states that an acid is an H^+ donor and a base is an H^+ acceptor.	
The acidity and alkalinity of an aqueous solution can be measured by its pH value. The relative level of acidity or alkalinity of a solution can be shown by using indicators.	interpret changes in acid-base indicator color identify solutions as acid, base, or neutral based upon the pH
On the pH scale, each decrease of one unit of pH represents a tenfold increase in hydronium (H^+) ion concentration.	

10. Nuclear Chemistry	
Major Understandings	Skills, students should be able to:
Stability of isotopes is based on the ratio of the neutrons and protons in its nucleus. Although most nuclei are stable, some are unstable and spontaneously decay emitting radiation.	
Each radioactive isotope has a specific mode and rate of decay (half-life).	calculate the initial amount, the fraction remaining, or the half life of a radioactive isotope, given two of the three variables
A change in the nucleus of an atom that converts it from one element to another is called transmutation. This can occur naturally or can be induced by the bombardment of the nucleus by high-energy particles.	
Spontaneous decay can involve the release of alpha particles, beta particles, positrons, and/or gamma radiation from the nucleus of an unstable isotope. These emissions differ in mass, charge, ionizing power, and penetrating power.	determine decay mode and write nuclear equations showing alpha and beta decay
Nuclear reactions include natural and artificial transmutation, fission, and fusion.	compare and contrast fission and fusion reactions
There are benefits and risks associated with fission and fusion reactions.	
Nuclear reactions can be represented by equations that include symbols which represent atomic nuclei (with the mass number and atomic number), subatomic particles (with mass number and charge), and/or emissions such as gamma radiation.	complete nuclear equations; predict missing particles from nuclear equations
Energy released in a nuclear reaction (fission or fusion) comes from the fractional amount of mass converted into energy. Nuclear changes convert matter into energy.	
Energy released during nuclear reactions is much greater than the energy released during chemical reactions.	
There are inherent risks associated with radioactivity and the use of radioactive isotopes. Risks can include biological exposure, long-term storage and disposal, and nuclear accidents.	
Radioactive isotopes have many beneficial uses. Radioactive isotopes are used in medicine and industrial chemistry, e.g., radioactive dating, tracing chemical and biological processes, industrial measurement, nuclear power, and detection and treatment of diseases.	identify specific uses of some common radioisotopes, such as: I-131 in diagnosing and treating thyroid disorders; C-14 to C-12 ratio in dating living organisms; U-238 to Pb-206 ratio in dating geological formations; Co-60 in treating cancer