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(1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to: **(A)** demonstrate safe practices during laboratory and field investigations, including the appropriate use of safety showers, eyewash fountains, safety goggles, and fire extinguishers; **(B)** know specific hazards of chemical substances such as flammability, corrosiveness, and radioactivity as summarized on the Material Safety Data Sheets (MSDS); and **(C)** demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials. **(2) Scientific processes. The student uses scientific methods to solve investigative questions. The student is expected to:** **(A)** know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section; **(B)** know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power which have been tested over a wide variety of conditions are	**Science Practices** **Standard SP.1: Scientific Questions and Predictions** **Asking scientific questions that can be tested empirically and structuring these questions in the form of testable predictions** **SP.1.1 Scientific Questions** Students recognize, formulate, justify and revise scientific questions that can be addressed by science in order to construct explanations. **SP.1.2 Predictions** Students make and justify predictions concerning natural phenomena. Predictions and justifications are based on observations of the world, on knowledge of the discipline and on empirical evidence. **Standard SP.2: Generation of Evidence: Collecting data to address scientific questions and to support predictions** **SP.2.1 Data Collection** Students select and use appropriate measurement methods and techniques for gathering data, and systematically record and organize observations and measurements.	**I. Nature of Science: Scientific Ways of Learning and Thinking** **A. Cognitive skills in science** **1.** Utilize skepticism, logic, and professional ethics in science. **2.** Use creativity and insight to recognize and describe patterns in natural phenomena. **3.** Formulate appropriate questions to test understanding of natural phenomena. **4.** Rely on reproducible observations of empirical evidence when constructing, analyzing, and evaluating explanations of natural events and processes. **B. Scientific inquiry** **1.** Design and conduct scientific investigations In which hypotheses are formulated and tested. **C. Collaborative and safe working practices** **1.** Collaborate on joint projects. **2**. Understand and apply safe procedures in the laboratory and field, including chemical, electrical, and fire safety and safe handling of live or preserved organisms. **3**. Demonstrate skill in the safe use of a wide variety of apparatuses, equipment, techniques, and procedures. **D. Current scientific technology** **1.** Demonstrate literacy in computer use. **2.** Use computer models, applications, and simulations. **3.** Demonstrate appropriate use of a wide

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incorporated into theories; **(C)** know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well-established and highly-reliable explanations, but may be subject to change as new areas of science and new technologies are developed; **(D)** distinguish between scientific hypotheses and scientific theories; **(E)** plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting equipment and technology, including graphing calculators, computers and probes, sufficient scientific glassware such as beakers, Erlenmeyer flasks, pipettes, graduated cylinders, volumetric flasks, safety goggles, and burettes, electronic balances, and an adequate supply of consumable chemicals; **(F)** collect data and make measurements with accuracy and precision; **(G)** express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures; **(H)** organize, analyze, evaluate, make inferences, and predict trends from data; and	**SP.2.2 Evaluating Data for Evidence** Students determine which data from a specific investigation can be used as evidence to address a scientific question or to support a prediction or an explanation, and distinguish credible data from noncredible data in terms of quality. **Standard SP.3: Data Analysis** **Searching for regularities and patterns in observations and measurements (i.e., data analysis)** **SP.3.1 Analyzing Data for Patterns** Students analyze data to discover patterns. **Standard SP.4:Evidence-Based Explanations and Models :** **Using evidence and science knowledge to construct scientific explanations, models and representations** **SP.4.1 Constructing Explanations** Students construct explanations that are based on observations and measurements of the world, on empirical evidence and on reasoning grounded in the theories, principles and concepts of the discipline. **SP.4.2 Models and Representations** Students construct, use, re-express and revise models and representations of natural and designed objects, systems,	variety of apparatuses, equipment, techniques, and procedures for collecting quantitative and qualitative data. **E. Effective communication of scientific information** **1.** Use several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic. **2.** Use essential vocabulary of the discipline being studied. **II. Foundation Skills: Scientific Applications of Mathematics** **A. Basic mathematics conventions** **1**. Understand the real number system and its properties. **2.** Use exponents and scientific notation. **3.** Understand ratios, proportions, percentages, and decimal fractions, and translate from any form to any other. **4.** Use proportional reasoning to solve problems. **5.** Simplify algebraic expressions. **6.** Estimate results to evaluate whether a calculated result is reasonable. **7**. Use calculators, spreadsheets, computers, etc., in data analysis.

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(I) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphs, journals, summaries, oral reports, and technology-based reports. **(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:** **(A)** in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student; **(B)** communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials; **(C)** draw inferences based on data related to promotional materials for products and services; **(D)** evaluate the impact of research on scientific thought, society, and the environment; **(E)** describe the connection between chemistry and future careers; and	phenomena and scientific ideas in the appropriate context and in formulating their explanation. **SP.4.3 Evaluating Explanations** Students evaluate, compare and contrast explanations that are based on observations of the world, on empirical evidence and on reasoning grounded in the theories, principles and concepts of the discipline. **Standard SP.5:Quantitative Applications** **Using mathematical reasoning and quantitative applications to interpret and analyze data to solve problems** **SP.5.1 Proportionality Between Variables** Students reason about relationships between variables (e.g., data, representations, uncertainty, samples) through the lens of ratios, rates, percentages, probability or proportional relationships when approaching or solving problems or when interpreting results or situations. **SP.5.2 Patterns of Bivariate Relationships** Students apply, analyze and create algebraic representations, relationships and patterns of linear functions, systems of linear inequalities, and one- or two-dimensional changes to solve problems, interpret situations and address scientific questions.	**B. Mathematics as a symbolic language** **1**. Carry out formal operations using standard algebraic symbols and formulae. **2.** Represent natural events, processes, and relationships with algebraic expressions and algorithms. **C. Understand relationships among geometry, algebra, and trigonometry** **1.** Understand simple vectors, vector notations, and vector diagrams, and carry out simple calculations involving vectors. **2.** Understand that a curve drawn on a defined set of axes is fully equivalent to a set of algebraic equations. **3.** Understand basic trigonometric principles, Including definitions of terms, such as sine, cosine, tangent, cotangent, and their relationship to triangles. **4.** Understand basic geometric principles. **D. Scientific problem solving** **1.** Use dimensional analysis in problem solving. **E. Scientific application of probability and statistics** **1**. Understand descriptive statistics. **F. Scientific measurement** **1.** Select and use appropriate Standard International (SI) units and prefixes to express measurements for real world problems. **2.** Use appropriate significant digits. **3**. Understand and use logarithmic notation

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(F) research and describe the history of chemistry and contributions of scientists. **(4) Science concepts. The student knows the characteristics of matter and can analyze the relationships between chemical and physical changes and properties. The student is expected to:** **(A)** differentiate between physical and chemical changes and properties; **(B)** identify extensive and intensive properties; **(C)** compare solids, liquids, and gases in terms of compressibility, structure, shape, and volume; and **(D)** classify matter as pure substances or mixtures through investigation of their properties. **(5) Science concepts. The student understands the historical development of the Periodic Table and can apply its predictive power. The student is expected to:** **(A)** explain the use of chemical and physical properties in the historical development of the Periodic Table; **(B)** use the Periodic Table to identify and explain the properties of chemical families, including alkali metals, alkaline earth metals, halogens, noble gases, and transition metals; and	**Science, Technology and Society** **Standard STS.1:Science, Technology and Society** **A critical interdependence exists among science, technology and society.** **STS.1.1 Interdependence of Science and Technology** Students explain the interdependence of science and technology: how the ongoing development of technology relies on the advancements of science while scientific research relies on technological progress. Students understand how the evolution of various technologies (e.g., biotechnology, seismology, computational software, lasers) radically alters the practice of many science disciplines by affecting the quality and quantity of available data. **STS.1.2 Advantages and Disadvantages to Society** Students understand how science and technology together can be used for the benefit of society as well as their own lives (e.g., weather predictions, development of medications, creation of safety devices in cars), but that some technological capabilities (e.g., cloning, genetic recombination, nuclear energy studies, access to fossil fuels, chemical engineering)	(base 10). **III. Foundation Skills: Scientific Applications of Communication** **A. Scientific writing** **1.** Use correct applications of writing practices in scientific communication. **B. Scientific reading** **1.** Read technical and scientific articles to gain understanding of interpretations, apparatuses, techniques or procedures, and data. **2.** Set up apparatuses, carry out procedures, and collect specified data from a given set of appropriate instructions. **3.** Recognize scientific and technical vocabulary In the field of study and use this vocabulary to enhance clarity of communication. **4.** List, use, and give examples of specific strategies before, during, and after reading to improve comprehension. **C. Presentation of scientific/technical information** **1.** Prepare and present scientific/technical information in appropriate formats for various audiences. **D. Research skills/information literacy** **1.** Use search engines, databases, and other digital electronic tools effectively to locate information. **2.** Evaluate quality, accuracy, completeness,

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(C) use the Periodic Table to identify and explain periodic trends, including atomic and ionic radii, electronegativity, and ionization energy. **(6) Science concepts. The student knows and understands the historical development of atomic theory. The student is expected to:** **(A)** understand the experimental design and conclusions used in the development of modern atomic theory, including Dalton's Postulates, Thomson's discovery of electron properties, Rutherford's nuclear atom, and Bohr's nuclear atom; **(B)** understand the electromagnetic spectrum and the mathematical relationships between energy, frequency, and wavelength of light; **(C)** calculate the wavelength, frequency, and energy of light using Planck's constant and the speed of light; **(D)** use isotopic composition to calculate average atomic mass of an element; and **(E)** express the arrangement of electrons in atoms through electron configurations and Lewis valence electron dot structures. **(7) Science concepts. The student knows how atoms form ionic, metallic, and covalent bonds. The student is expected to:** **(A)** name ionic compounds containing main	create ethical and economic dilemmas for society. **STS.1.3 Evaluating Online Information** Students recognize that the amount of information, as well as access to information, has exploded since the creation of the Internet. Online information should be judged using the same science practices and critical and skeptical views that reflect the way science is conducted and evaluated. Students also recognize the relationship between digital technology and the **fact** that social networking is a source of information generation and of the determination of "truths" in our current society. Students understand that this information presents a specific perspective that is not backed by research; therefore, the information and the perspective do not represent the empirical reality of science. **Standard C.1: Structure of Matter** **Matter is composed of small particles called atoms that are in constant motion and that combine in various predictable ways.** **C.1.1 Atomic Theories** Students understand the current model of atomic structure, how the model has changed over time, and how experimental evidence about atomic structure has led to	reliability, and currency of information from any sources. **IV. Science, Technology, and Society** **A. Interactions between innovations and science** **1.** Recognize how scientific discoveries are connected to technological innovations. **B. Social ethics** **1.** Understand how scientific research and technology have an impact on ethical and legal practices. **2.** Understand how commonly held ethical beliefs impact scientific research. **C. History of science** **1.** Understand the historical development of major theories in science. **2.** Recognize the role of people in important contributions to scientific knowledge. **V. Cross-Disciplinary Themes** **A. Matter/states of matter** **1.** Know modern theories of atomic structure. **2.** Understand the typical states of matter (solid, liquid, gas) and phase changes among these. **B. Energy (thermodynamics, kinetic, potential, energy transfers)** **1.** Understand the Laws of Thermodynamics. **2.** Know the processes of energy transfer.

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group or transition metals, covalent compounds, acids, and bases, using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules; **(B)** write the chemical formulas of common polyatomic ions, ionic compounds containing main group or transition metals, covalent compounds, acids, and bases; **(C)** construct electron dot formulas to illustrate ionic and covalent bonds; **(D)** describe the nature of metallic bonding and apply the theory to explain metallic properties such as thermal and electrical conductivity, malleability, and ductility; and **(E)** predict molecular structure for molecules with linear, trigonal planar, or tetrahedral electron pair geometries using Valence Shell Electron Pair Repulsion (VSEPR) theory. **(8) Science concepts. The student can quantify the changes that occur during chemical reactions. The student is expected to:** **(A)** define and use the concept of a mole; **(B)** use the mole concept to calculate the number of atoms, ions, or molecules in a sample of material; **(C)** calculate percent composition and empirical and molecular formulas; **(D)** use the law of conservation of mass to write and balance chemical equations; and	changes in the atomic model. **C.1.2 Electrons** Students understand that the interactions of electrons between and within atoms are the primary factors that determine the properties of matter. **C.1.3 Bonding** Students understand that matter is composed of atoms of elements, most of which are bonded in different but predictable ways. **C.1.4 Representations of Matter** Students understand that atoms, molecules and ionic substances can be represented with a variety of models. **C.1.5 States of Matter** Students understand that matter exists in different states, and that these states are determined by atomic–molecular level structure, attractions between particles, and the relative motions of particles. **C.1.6 Nuclear Chemistry** Students understand that changes occurring in the nucleus of an atom may alter the identity of an atom and often result in large changes in energy. **Standard C.2: Matter and Change** **The properties of matter and the changes that matter undergoes result from its**	**C. Change over time/equilibrium** **1.** Recognize patterns of change. **D. Classification** **1.** Understand that scientists categorize things according to similarities and differences. **E. Measurements and models** **1.** Use models to make predictions. **2.** Use scale to relate models and structures. **3.** Demonstrate familiarity with length scales from sub-atomic particles through macroscopic objects. **VII. Chemistry** **A. Matter and its properties** **1.** Know that physical and chemical properties can be used to describe and classify matter. **2.** Recognize and classify pure substances (elements, compounds) and mixtures. **B. Atomic structure** **1.** Summarize the development of atomic theory. Understand that models of the atom are used to help understand the properties of elements and compounds. **C. Periodic table** **1.** Know the organization of the periodic table. **2.** Recognize the trends in physical and chemical properties as one moves across a period or vertically through a group. **D. Chemical bonding** **1**. Characterize ionic bonds, metallic bonds, and

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(E) perform stoichiometric calculations, including determination of mass relationships between reactants and products, calculation of limiting reagents, and percent yield. **(9) Science concepts. The student understands the principles of ideal gas behavior, kinetic molecular theory, and the conditions that influence the behavior of gases. The student is expected to:** **(A)** describe and calculate the relations between volume, pressure, number of moles, and temperature for an ideal gas as described by Boyle's law, Charles' law, Avogadro's law, Dalton's law of partial pressure, and the ideal gas law; **(B)** perform stoichiometric calculations, including determination of mass and volume relationships between reactants and products for reactions involving gases; and **(C)** describe the postulates of kinetic molecular theory. **(10) Science concepts. The student understands and can apply the factors that influence the behavior of solutions. The student is expected to:** **(A)** describe the unique role of water in chemical and biological systems; **(B)** develop and use general rules regarding	**atomic–molecular level structure. For any chemical or physical change, matter is conserved.** **C.2.1 Periodic Table** Students understand that the periodic table is an organizational tool that can be used for the prediction and classification of the trends and properties of elements. **C.2.2 Structure–Property Relationships** Students understand the relationship between molecular-level structure and chemical and physical properties. **C.2.3 Conservation of Matter** Students understand that matter is conserved whenever any change occurs. **C.2.4 Chemical Equilibrium** Students understand that many reactions do not proceed completely from reactants to products; instead, reactions reach a state of dynamic equilibrium where the amounts of reactants and products appear constant. **C.2.5 Chemical Kinetics** Students understand that for a chemical reaction to occur, reacting particles must collide in the appropriate orientation with enough energy to overcome the activation energy barrier.	covalent bonds. Describe the properties of metals and ionic and covalent compounds. **C. Periodic table** **1.** Know the organization of the periodic table. **2.** Recognize the trends in physical and chemical properties as one moves across a period or vertically through a group. **D. Chemical bonding** **1.** Characterize ionic bonds, metallic bonds, and covalent bonds. Describe the properties of metals and ionic and covalent compounds. **E. Chemical reactions** **1.** Classify chemical reactions by type. Describe the evidence that a chemical reaction has occurred. **2.** Describe the properties of acids and bases, and identify the products of a neutralization reaction. **3**. Understand oxidation-reduction reactions. **4.** Understand chemical equilibrium. **5.** Understand energy changes in chemical Reactions. **6**. Understand chemical kinetics. **F. Chemical nomenclature** **1.** Know formulas for ionic compounds. **2.** Know formulas for molecular compounds. **G. The mole and stoichiometry** **1.** Understand the mole concept. **2.** Understand molar relationships in reactions, stoichiometric calculations, and percent yield.

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solubility through investigations with aqueous solutions; **(C)** calculate the concentration of solutions in units of molarity; **(D)** use molarity to calculate the dilutions of solutions; **(E)** distinguish between types of solutions such as electrolytes and nonelectrolytes and unsaturated, saturated, and supersaturated solutions; **(F)** investigate factors that influence solubilities and rates of dissolution such as temperature, agitation, and surface area; **(G)** define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions and predict products in acid base reactions that form water; **(H)** understand and differentiate among acid-base reactions, precipitation reactions, and oxidation-reduction reactions; **(I)** define pH and use the hydrogen or hydroxide ion concentrations to calculate the pH of a solution; and **(J)** distinguish between degrees of dissociation for strong and weak acids and bases. **(11) Science concepts. The student understands the energy changes that occur in chemical reactions. The student is expected to:**	**Standard C.3: Energy and Change** **When any change occurs, energy is transferred and/or transformed, but it is never lost.** **C.3.1 Conservation of Energy** Students understand that energy is conserved during any change — energy may be transformed into another type of energy, but it never disappears. **C.3.2 Energy Transfers and Transformations** Students understand that when any change occurs, energy is transferred or transformed; some energy (in the form of thermal energy) always spreads out, making it more difficult to effect further change. **C.3.3 Chemical Energy** Students understand that energy changes associated with chemical reactions are a result of the rearrangement of atoms in a chemical system.	**H. Thermochemistry** **1.** Understand the Law of Conservation of Energy and processes of heat transfer. **2.** Understand energy changes and chemical reactions. **I. Properties and behavior of gases, liquids, and solids** **1.** Understand the behavior of matter in its various states: solid, liquid, and gas. **2.** Understand properties of solutions. **3.** Understand principles of ideal gas behavior and kinetic molecular theory. **4.** Apply the concept of partial pressures in a mixture of gases. **5.** Know properties of liquids and solids. **6.** Understand the effect of vapor pressure on changes in state; explain heating curves and phase diagrams. **7.** Describe intermolecular forces. **J. Basic structure and function of biological molecules: proteins, carbohydrates, lipids, and nucleic acids** **1.** Understand the major categories of biological molecules: proteins, carbohydrates, lipids, and nucleic acids. **K. Nuclear chemistry** **1.** Understand radioactive decay.

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(A) understand energy and its forms, including kinetic, potential, chemical, and thermal energies; **(B)** understand the law of conservation of energy and the processes of heat transfer; **(C)** use thermochemical equations to calculate energy changes that occur in chemical reactions and classify reactions as exothermic or endothermic; **(D)** perform calculations involving heat, mass, temperature change, and specific heat; and **(E)** use calorimetry to calculate the heat of a chemical process. **(12) Science concepts. The student understands the basic processes of nuclear chemistry. The student is expected to:** **(A)** describe the characteristics of alpha, beta, and gamma radiation; (B) describe radioactive decay process in terms of balanced nuclear equations; and **(C)** compare fission and fusion reactions.		