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Standard CHEM.1.1	Obtain, evaluate, and communicate information regarding the structure of the atom on the basis of experimental evidence. Emphasize the relationship between proton number and element identity, isotopes, and electrons in atoms. Examples of experimental evidence could include the gold foil experiment, cathode ray tube, or atomic spectrum data. (PS1.A)	**pp. 100–124 Chapter 4: Atoms and Elements** — atomic structure, proton number and element identity, isotopes, electrons in atoms; cathode ray tube (p. 109) and gold foil experiment (p. 110); **pp. 130–131** atomic spectrum data and electron energy levels
Standard CHEM.1.2	Analyze and interpret data to identify patterns in the stability of isotopes and predict likely modes of radioactive decay. Emphasize that different isotopes of the same element decay by different modes and at different rates depending on their nuclear stability. Examples of data could include band of stability charts, mass or nuclear binding energy per nucleon, or the inverse relationship between half-life and nuclear stability. (PS1.C)	**pp. 508–529** Chapter 16: Nuclear Chemistry — natural radioactivity, nuclear reactions (alpha, beta, positron, and gamma decay), radiation measurement
Standard CHEM.1.3	Use mathematics and computational thinking to relate the rates of change in quantities of radioactive isotopes through radioactive decay (alpha, beta, and positron) to ages of materials or persistence in the environment. Emphasize a conceptual understanding of half-life. Examples could include radiocarbon dating, nuclear waste management, or nuclear medicine. (PS1.C)	**pp. 527–531** half-life calculations; radioactivity in medical imaging; nuclear medicine
Standard CHEM.1.4	Construct an explanation about how fusion can form new elements with greater or lesser nuclear stability. Emphasize the nuclear binding energy, with the conceptual understanding that when fusion of elements results in a more stable nucleus, large quantities of energy are released, and when fusion results in a less stable nucleus, large quantities of energy are required. Examples could include the building up of elements in the universe starting with hydrogen to form heavier elements, the composition of stars, or supernovae producing heavy elements. (PS1.C, ESS1.A)	**pp. 530–531** fusion, nuclear stability, and energy released in fusion reactions
Standard CHEM.1.5	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. Emphasize conceptual understanding of trends and patterns. Examples could include trends in ionization energy, atomic radius, or electronegativity. Examples of properties for main group elements could include general reactivity, bonding type, or ion formation. (PS1.A)	**pp. 144–149** valence electrons and periodic trends (atomic radius, ionization energy, metallic character); exercises predicting periodic properties; **pp. 158-161** octet rule, ionic and covalent bonds

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Standard CHEM.2.1	Analyze data to predict the type of bonding most likely to occur between two elements using the patterns of reactivity on the periodic table. Emphasize the types and strengths of attractions between charged particles in ionic, covalent, and metallic bonds. Examples could include the attraction between electrons on one atom and the nucleus of another atom in a covalent bond or between ions in an ionic compound. (PS1.A, PS2.B)	**pp. 156-182** Chapter 6: Ionic and Molecular Compounds – ionic, covalent, and metallic bonding; **pp. 271-276** Lewis structures and bond formation; **pp. 284-287** electronegativity and bond polarity
Standard CHEM.2.2	Plan and carry out an investigation to compare the properties of substances at the bulk scale and relate them to molecular structures. Emphasize using models to explain or describe the strength of electrical forces between particles. Examples of models could include Lewis dot structures or ball and stick models. Examples of particles could include ions, atoms, molecules, or networked materials (such as graphite). Examples of properties could include melting point and boiling point, vapor pressure, solubility, or surface tension. (PS1.A)	**pp. 289–299** intermolecular forces; melting, freezing, and boiling points; **pp. 271-276** Lewis structures; **p. 305** Challenge Problems
Standard CHEM.2.3	Engage in argument supported by evidence that the functions of natural and designed macromolecules are related to their chemical structures. Emphasize the roles of attractive forces between and within molecules. Examples could include non-covalent interactions between base pairs in DNA allowing it to be unzipped for replication, the network of atoms in a diamond conferring hardness, or the nonpolar nature of polyester (PET) making it quick-drying. (PS1.A)	**pp. 289-291** intermolecular forces; **pp. 552–557** polymers (macromolecules) and organic molecular structures
Standard CHEM.2.4	Evaluate design solutions where synthetic chemistry was used to solve a problem (cause and effect). Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Emphasize the design of materials to control their properties through chemistry. Examples could include pharmaceuticals that target active sites, teflon to reduce friction on surfaces, or nanoparticles of zinc oxide to create transparent sunscreen. (PS1.A, ETS1.A, ETS1.B, ETS1.C)	**p. 125** materials engineers developing semiconductor materials; **p. 585** Understanding the Concepts - 17.73 (Teflon), 17.74 (PVC)

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Standard CHEM.3.1	Use mathematics and computational thinking to analyze the distribution and proportion of particles in solution. Emphasize proportional reasoning and the impact of concentration on solution properties, rather than algorithmic calculations. Examples of concentrations affecting solutions could include the Beer-Lambert Law, colligative properties, or pH. (PS1.A)	**pp. 352-397** Chapter 12: Solutions – concentration, solubility, electrical conductivity, colligative properties, pH
Standard CHEM.3.2	Analyze data to identify patterns that assist in making predictions of the outcomes of simple chemical reactions. Emphasize patterns based on the outermost electrons of atoms, trends in the periodic table, and knowledge of chemical properties. Examples could include reactions between main group elements, combustion reactions, or reactions between Arrhenius acids and bases. (PS1.B)	**pp. 227–239** types of chemical reactions and oxidation–reduction reactions; **pp. 140–149** electron configurations and periodic trends that explain chemical reactivity; **pp. 455-456** reactions of acids and bases
Standard CHEM.3.3	Plan and carry out an investigation to observe the change in properties of substances in a chemical reaction to relate the macroscopically observed properties to the molecular level changes in bonds and the symbolic notation used in chemistry. Emphasize that the visible macroscopic changes in chemical reactions are a result of changes on the molecular level. Examples of observable properties could include changes in color or the production of a solid or gaseous product. (PS1.B)	**pp. 223–232** types of chemical reactions (combination, decomposition, single replacement, double replacement), combustion and oxidation–reduction reactions; text does not assign an investigation
Standard CHEM.3.4	Use mathematics and computational thinking to support the observation that matter is conserved during chemical reactions and matter cycles. Emphasize that chemical reactions occur on both small and global scales, and that matter is always conserved. Examples of small scale reactions could include ratios of reactants and products in a single chemical reaction or simple stoichiometric calculation. Examples of global scale matter cycles could include tracing carbon through the chemical reactions of photosynthesis, combustion, or respiration. (PS1.B)	**pp. 213–233** Chapter 8: Chemical Reactions — writing and balancing chemical equations; **pp. 241–253** Chapter 9: Chemical Quantities in Reactions — conservation of mass, mole relationships, stoichiometric calculations, limiting reactants, and percent yield

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Standard CHEM.3.5	Develop solutions related to the management, conservation, and utilization of mineral resources (matter). Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize the conservation of matter and minerals as a limited resource. Examples of Utah mineral resources could include copper, uranium, potash, coal, oil, or natural gas. Examples of constraints could include cost, safety, reliability, or possible social, cultural, and environmental impacts. (PS1.B, ESS3.A, ETS1.A, ETS1.B, ETS1.C)	**p. 496** fuel cells as an alternative energy technology; discusses efficiency, reduced use of oil reserves, reduced pollution, and design improvements needed before widespread use
Standard CHEM.3.	Construct an explanation using experimental evidence for how reaction conditions affect the rate of change of a reaction. Emphasize collision theory as an explanatory principle. Examples of reaction conditions could include temperature, concentration, particle size, or presence of a catalyst. (PS1.B)	**pp. 400–403** collision theory and effects of temperature, concentration, and catalysts on reaction rates; **pp. 427-428** practice problems
Standard CHEM.3.7	Design a solution that would refine a chemical system by specifying a change in conditions that would produce increased or decreased amounts of a product at equilibrium. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize a qualitative understanding of Le Châtelier's Principle and connections between macroscopic and molecular level changes. (PS1.B, ETS1.A, ETS1.B, ETS1.C)	**pp. 415–420** Le Châtelier's principle and predicting equilibrium shifts when conditions change
Standard CHEM.3.8	Obtain, evaluate, and communicate information regarding the effects of designed chemicals in a complex real-world system. Emphasize the role of chemistry in solving problems, while acknowledging unintended consequences. Examples could include ozone depletion and restoration, DDT, development of medicines, the preservation of historical artifacts, or use of bisphenol-A in plastic manufacturing. (PS1.A)	**p. 156** aspirin uses and side effects; **pp. 495-496** fuel cell benefits and limitations; **pp. 527-529** medical applications of radioactivity

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Standard CHEM.4.1	Construct an argument from evidence about whether a simple chemical reaction absorbs or releases energy. Emphasize that the overall change in energy is related to the energy absorbed when bonds are broken and the energy released when bonds are formed. Examples could include chemical reactions releasing or absorbing energy to or from the surrounding solution or the metabolism of glucose. (PS1.B, PS3.B)	**pp. 255–261** exothermic and endothermic reactions; **pp. 265-266** practice problems such as 9.71-9.72, 9.79-9.80
Standard CHEM.4.2	Construct an explanation of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. Emphasize a qualitative understanding. Examples could include that low energy electromagnetic radiation can increase molecular rotation and bond vibration, visible light can cause electronic transitions, and high energy electromagnetic radiation can result in ionization and bond breaking. (PS4.B)	**pp. 127–131** electromagnetic radiation, atomic spectra, and electron energy levels; absorption and emission of electromagnetic radiation causing electronic transitions
Standard CHEM.4.3	Design a device that converts energy from one form into another to solve a problem. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize chemical potential energy as a type of stored energy. Examples of sources of chemical potential energy could include oxidation-reduction or combustion reactions. (PS3.B, ETS1.A, ETS1.B, ETS1.C)	**pp. 490–500** voltaic cells, batteries, fuel cells, and electrochemical energy conversion; discusses existing devices rather than having students design one
Standard CHEM.4.4	Use models to describe the changes in the composition of the nucleus of the atom during nuclear processes, and compare the energy released during nuclear processes to the energy released during chemical processes. Emphasize a qualitative understanding of nuclear changes. Examples of nuclear processes could include the formation of elements through fusion in stars, generation of electricity in a nuclear power plant, radioactive decay, or the use of radioisotopes in nuclear medicine. (PS1.C, PS3.D)	**pp. 508-538** Chapter 16: Nuclear Chemistry — radioactive decay, fission, fusion, and comparison of nuclear energy processes

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Standard CHEM.4.5	Develop an argument from evidence to evaluate a proposed solution to societal energy demands based on prioritized criteria and trade-offs that account for a range of constraints that could include cost, safety, reliability, as well as possible social, cultural, and environmental impacts. (PS3.D, ETS1.A, ETS1.B, ETS1.C)	**pp. 490–500** fuel cells and batteries—alternative energy technologies, efficiency, and environmental benefits; **pp. 530–537** nuclear fission and fusion, energy production, radioactive waste; text discusses trade-offs but does not include an engineering evaluation of proposed energy solutions