Utah	Chemistry Standards	Introductory Chemistry 7e
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. 106-126** Chapter 4: Atoms and Elements sections 4.2 to 4.9; includes gold foil experiment (p. 107); **pp. 130–131** end-of-chapter exercises; **pp. 295-302** electromagnetic radiation and atomic emission spectra; **p. 322** the Bohr and quantum-mechanical models
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. 615-627** radioactivity discovery and types, half-life, radiocarbon dating
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. 623-627** radioactive decay, half-life, radiocarbon dating; **p. 634** radioactivity in medicine; **pp. 638-643** end-of-chapter exercises
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. 628-632** nuclear fusion, fusion in stars, energy released

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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. 316-320** electron configurations, periodic trends in atomic size, ionization energy, and metallic character; **pp. 325-330** exercises
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. 333–349** valence electrons, Lewis structures, ion formation, bonding types, electronegativity, and polarity; **pp. 357-364** exercises classifying compounds as ionic or covalent
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. 336-353** molecular geometry (VSEPR), Lewis structures and electron geometry, bond angles, electronegativity, bond polarity, molecular polarity, and relationships between molecular structure and physical properties; **pp. 357-364** exercises; **pp. 430-440** intermolecular forces, crystalline solids, properties of water
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. 675–677** polymers and relationships between chemical structure and material function/properties; **pp. 349–353** bond polarity, molecular polarity, and structure-property relationships (oil/water interactions and soap); **pp. 418–420** properties of liquids and solids and intermolecular forces; **pp. 430–440** intermolecular forces and properties of water

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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)	**pp. 675–677** synthetic polymers, polymer structures, and relationships between chemical structure and designed material properties, including PET and Kevlar
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. 456–468** concentration, solution composition, and colligative properties; **pp. 482–490** exercises; **pp. 224–235** aqueous solutions, solubility, and 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. 313-315** valence electrons, periodic trends, predictable ion formation, and relationships between electron configurations and chemical reactivity; **pp. 221-255** predicting and writing precipitation, acid–base, gas-evolution, redox, and combustion reactions; determining solubility; classifying chemical reactions
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. 216-235** chemical reactions; **pp. 248-255** exercises; **pp. 499-505** reactions of acids and bases; acid-base titration

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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)	**p. 6** law of conservation of mass; **pp. 73–75** physical and chemical changes in matter; **pp. 256-291** Chapter 8: Quantities in Chemical Reactions; **p. 220** and **p. 249** balanced equation for photosynthesis; pp. **584–589** photosynthesis and respiration
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)	**pp. 630–631** nuclear power generation with uranium, including benefits and risks of nuclear energy; **pp. 124–126** management of radioactive waste; **p. 401** sulfur dioxide air pollution from metal refining
Standard CHEM.3.6	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. 535-537** the rate of a chemical reaction - collision theory, temperature, concentration; **pp. 557-561** effect of a catalyst; **p. 567** problems 37-42
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. 537–555** dynamic equilibrium, factors affecting equilibrium, Le Châtelier's Principle, and equilibrium constants; **pp. 556–574** end-of-chapter exercises

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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. 177** chlorofluorocarbons (CFCs) and ozone depletion; **pp. 630–634** nuclear fission, radioactive isotopes, and their beneficial and harmful effects; **p. 125** radioactive waste management; **p. 401** sulfur dioxide and other emissions from electricity generation, motor vehicles, and industrial processes
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. 79-80** exothermic and endothermic reactions; **p. 98** problems 65-68; **pp. 273-275** enthalpy; **pp. 426-427** energetics of melting, freezing, and vaporization
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. 295-310** electromagnetic radiation, electromagnetic spectrum, the Bohr model, quantum-mechanical model and electron configurations; **pp. 324-330** end-of-chapter exercises about electromagnetic radiation, photon energy, electronic transitions, and bond breaking by high-energy radiation
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)	**p. 78** chemical energy (chemical potential energy) defined; **p. 215** combustion reactions; **pp. 576–611** oxidation-reduction reactions; voltaic cells (batteries) converting chemical potential energy to electrical energy; electrolysis (electrical to chemical energy); corrosion and corrosion prevention

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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. 612-643** Chapter 17: Radioactivity and Nuclear Chemistry – types of radioactivity, half-life, radiocarbon dating, nuclear fusion and fusion, radioisotopes in medicine
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. 594-598** batteries, voltaic cells; **pp. 630-633** nuclear power, nuclear fusion, and effects of radiation on life; **p. 638** questions 42-46