

Chemistry

State Standard Number	State Standard Area/Description	Unit Name	Course Topic Description
C	Chemistry		
C1	<p>Students will understand the nature of science and demonstrate an ability to practice scientific reasoning by applying it to the design, execution, and evaluation of scientific investigations. Students will demonstrate their understanding that scientific knowledge is gathered through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. They will be able to distinguish between types of scientific knowledge (e.g., hypotheses, laws, theories) and become aware of areas of active research in contrast to conclusions that are part of established scientific consensus. They will use their scientific knowledge to assess the costs, risks, and benefits of technological systems as they make personal choices and participate in public policy decisions. These insights will help them analyze the role science plays in society, technology, and potential career opportunities.</p>		
C1.1	<p>Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.</p>		

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C1.1A	Generate new questions that can be investigated in the laboratory or field.		
C1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity-length, volume, weight, time interval, temperature-with the appropriate level of precision).	Unit 1: An Introduction to Chemistry	Section B: Scientific Measurements Section C: Safety in the Chemistry Lab
C1.1D	Identify patterns in data and relate them to theoretical models.		
C1.1E	Describe a reason for a given conclusion using evidence from an investigation.	Throughout the course	Lab assignments
C1.1f	Predict what would happen if the variables, methods, or timing of an investigation were changed.		
C1.1g	Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation		
C1.1h	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	Throughout the course	Lab assignments
C1.1i	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.2	The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science		

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	<p>can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.</p>		
C1.2A	Critique whether or not specific questions can be answered through scientific investigations.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	Throughout the course	Webquest assignments And Journal activities
C1.2D	Evaluate scientific explanations in a peer review process or discussion format.	Throughout the course	Discussion assignments
C1.2E	Evaluate the future career and occupational prospects of science fields.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.2f	Critique solutions to problems, given criteria and scientific constraints.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.2g	Identify scientific tradeoffs in design decisions and choose among alternative solutions.		
C1.2h	Describe the distinctions between scientific theories, laws, hypotheses, and observations.		

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C1.2i	Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.		
C1.2j	Apply science principles or scientific data to anticipate effects of technological design decisions.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.	Unit 1: An Introduction to Chemistry	Section A: Science and Society
C2	Students recognize the many forms of energy and understand that energy is central to predicting and explaining how and why chemical reactions occur. The chemical topics of bonding, gas behavior, kinetics, enthalpy, entropy, free energy, and nuclear stability are addressed in this standard. Chemistry students relate temperature to the average kinetic energy of the molecules and use the kinetic molecular theory to describe and explain the behavior of gases and the rates of chemical reactions. They understand nuclear stability in terms of reaching a state of minimum potential energy.		
P2.p1	Three forms of potential energy are gravitational, elastic, and chemical. Objects can have elastic potential energy due to their compression or chemical potential energy due to the arrangement of the atoms. (prerequisite)		
P2.p1A	Describe energy changes associated with changes of state in terms of the arrangement and order of the atoms (molecules) in each state. (prerequisite)	Unit 7: Solids, Liquids, and Gases	Section D: Changes in State
P2.p1B	Use the positions and arrangements of atoms and molecules in solid, liquid, and gas state to explain the need for an input of energy for melting and boiling and a release of energy in condensation and freezing. (prerequisite)	Unit 7: Solids, Liquids, and Gases	Section D: Changes in State

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C2.1x	Potential energy is stored whenever work must be done to change the distance between two objects. The attraction between the two objects may be gravitational, electrostatic, magnetic, or strong force. Chemical potential energy is the result of electrostatic attractions between atoms.		
C2.1a	Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.	Unit 5: Elements Form Compounds	Section A: Ionic Compounds
C2.1b	Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).	Unit 9: Chemical Thermodynamics and Equilibrium	Section D: Reaction Rates
C2.1c	Compare qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid.	Unit 7: Solids, Liquids, and Gases	Section C: Properties of Solids and Liquids
C2.2	Molecules that compose matter are in constant motion (translational, rotational, vibrational). Energy may be transferred from one object to another during collisions between molecules.		
C2.2A	Describe conduction in terms of molecules bumping into each other to transfer energy. Explain why there is better conduction in solids and liquids than gases.	Unit 7: Solids, Liquids, and Gases	Section C: Properties of Solids and Liquids
C2.2B	Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.	Unit 7: Solids, Liquids, and Gases	Section A: The Kinetic Molecular Theory
C2.2x	As temperature increases, the average kinetic energy and the entropy of the molecules in a sample increases.		
C2.2c	Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.	Unit 7: Solids, Liquids, and Gases	Section A: The Kinetic Molecular Theory Section B: Properties of Gases

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C2.2d	Explain convection and the difference in transfer of thermal energy for solids, liquids, and gases using evidence that molecules are in constant motion.		
C2.2e	Compare the entropy of solids, liquids, and gases.	Unit 9: Chemical Thermodynamics and Equilibrium	Section C: Laws of Thermodynamics
C2.2f	Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.	Unit 7: Solids, Liquids, and Gases	Section A: The Kinetic Molecular Theory
C2.3x	For molecules to react, they must collide with enough energy (activation energy) to break old chemical bonds before their atoms can be rearranged to form new substances.		
C2.3a	Explain how the rate of a given chemical reaction is dependent on the temperature and the activation energy.	Unit 9: Chemical Thermodynamics and Equilibrium	Section D: Reaction Rates
C2.3b	Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.	Unit 9: Chemical Thermodynamics and Equilibrium	Section D: Reaction Rates
C2.4x	For each element, the arrangement of electrons surrounding the nucleus is unique. These electrons are found in different energy levels and can only move from a lower energy level (closer to nucleus) to a higher energy level (farther from nucleus) by absorbing energy in discrete packets. The energy content of the packets is directly proportional to the frequency of the radiation. These electron transitions will produce unique absorption spectra for each element. When the electron returns from an excited (high energy state) to a lower energy state, energy is emitted in only certain wavelengths of light, producing an emission spectra.		
C2.4a	Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions.	Unit 3: Atomic Structure	Section D: Atomic Spectra and Quantum Mechanics

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C2.4b	Contrast the mechanism of energy changes and the appearance of absorption and emission spectra.	Unit 3: Atomic Structure	Section B: Atomic Structure
			Section D: Atomic Spectra and Quantum Mechanics
C2.4c	Explain why an atom can absorb only certain wavelengths of light.	Unit 3: Atomic Structure	Section D: Atomic Spectra and Quantum Mechanics
C2.4d	Compare various wavelengths of light (visible and nonvisible) in terms of frequency and relative energy.	Unit 3: Atomic Structure	Section D: Atomic Spectra and Quantum Mechanics
C2.5x	Nuclear stability is related to a decrease in potential energy when the nucleus forms from protons and neutrons. If the neutron/proton ratio is unstable, the element will undergo radioactive decay. The rate of decay is characteristic of each isotope; the time for half the parent nuclei to decay is called the half-life. Comparison of the parent/daughter nuclei can be used to determine the age of a sample. Heavier elements are formed from the fusion of lighter elements in the stars.		
C2.5a	Determine the age of materials using the ratio of stable and unstable isotopes of a particular type.	Unit 10: Nuclear Chemistry	Section D: Nuclear Energy
C2.r5b	Illustrate how elements can change in nuclear reactions using balanced equations. (recommended)	Unit 10: Nuclear Chemistry	Section A: Radioactivity
C2.r5c	Describe the potential energy changes as two protons approach each other. (recommended)		
C2.r5d	Describe how and where all the elements on earth were formed. (recommended)	Unit 10: Nuclear Chemistry	Section B: Nuclear Reactions
C3	Students apply the First and Second Laws of Thermodynamics to explain and predict most chemical phenomena. Chemistry students use the term enthalpy to describe the transfer of energy between reactants and products in simple		

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	calorimetry experiments performed in class and will recognize Hess's Law as an application of the conservation of energy. Students understand the tremendous energy released in nuclear reactions is a result of small amounts of matter being converted to energy.		
P3.p1	When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. (prerequisite)		
P3.p1A	Explain that the amount of energy necessary to heat a substance will be the same as the amount of energy released when the substance is cooled to the original temperature. (prerequisite)	Unit 9: Chemical Thermodynamics and Equilibrium	Section A: What is Heat? Section B: Calculating Enthalpy Changes
C3.1x	For chemical reactions where the state and amounts of reactants and products are known, the amount of energy transferred will be the same regardless of the chemical pathway. This relationship is called Hess's law.		
C3.1a	Calculate the delta H for a given reaction using Hess's Law.	Unit 9: Chemical Thermodynamics and Equilibrium	Section B: Calculating Enthalpy Changes
C3.1b	Draw enthalpy diagrams for exothermic and endothermic reactions.		
C3.1c	Calculate the delta H for a chemical reaction using simple coffee cup calorimetry.	Unit 9: Chemical Thermodynamics and Equilibrium	Section A: What is Heat? Section B: Calculating Enthalpy Changes
C3.1d	Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.	Unit 9: Chemical Thermodynamics and Equilibrium	Section B: Calculating Enthalpy Changes
P3.p2	Nuclear reactions take place in the sun. In plants, light from the sun is transferred to oxygen and carbon compounds, which, in combination, have chemical potential energy (photosynthesis). (prerequisite)		
P3.p2A	Trace (or diagram) energy transfers involving various types of energy including nuclear, chemical, electrical, sound, and light. (prerequisite)	Unit 9: Chemical Thermodynamics and Equilibrium	Section C: Laws of Thermodynamics

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C3.2x	Chemical reactions involve breaking bonds in reactants (endothermic) and forming new bonds in the products (exothermic). The enthalpy change for a chemical reaction will depend on the relative strengths of the bonds in the reactants and products.		
C3.2a	Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.		
C3.2b	Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms.		
C3.3	Heating increases the kinetic (translational, rotational, and vibrational) energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic (translational) energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a sample of a crystalline solid increases the kinetic (vibrational) energy of the atoms, molecules, or ions. When the kinetic (vibrational) energy becomes great enough, the crystalline structure breaks down, and the solid melts.		
C3.3A	Describe how heat is conducted in a solid.	Unit 7: Solids, Liquids, and Gases	Section D: Changes in State
		Unit 9: Chemical Thermodynamics and Equilibrium	Section B: Calculating Enthalpy Changes
C3.3B	Describe melting on a molecular level.	Unit 9: Chemical Thermodynamics and Equilibrium	Section B: Calculating Enthalpy Changes
C3.3x	Chemical bonds possess potential (vibrational and rotational) energy.		
C3.3c	Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond.	Unit 5: Elements Form Compounds	Section A: Ionic Compounds
		Unit 9: Chemical Thermodynamics and Equilibrium	Section D: Reaction Rates

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C3.4	Chemical interactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).		
C3.4A	Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.	Unit 9: Chemical Thermodynamics and Equilibrium	Section A: What is Heat? Section B: Calculating Enthalpy Changes
C3.4B	Explain why chemical reactions will either release or absorb energy.	Unit 9: Chemical Thermodynamics and Equilibrium	Section D: Reaction Rates
C3.4x	All chemical reactions involve rearrangement of the atoms. In an exothermic reaction, the products have less energy than the reactants. There are two natural driving forces: (1) toward minimum energy (enthalpy) and (2) toward maximum disorder (entropy).		
C3.4c	Write chemical equations including the heat term as a part of equation or using delta H notation.	Unit 9: Chemical Thermodynamics and Equilibrium	Section B: Calculating Enthalpy Changes
C3.4d	Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.		
C3.4e	Predict if a chemical reaction is spontaneous given the enthalpy (delta H) and entropy (delta S) changes for the reaction using Gibb's Free Energy, delta G = delta H - T delta S (Note: mathematical computation of delta G is not required.)	Unit 9: Chemical Thermodynamics and Equilibrium	Section C: Laws of Thermodynamics
C3.4f	Explain why some endothermic reactions are spontaneous at room temperature.	Unit 9: Chemical Thermodynamics and Equilibrium	Section C: Laws of Thermodynamics
C3.4g	Explain why gases are less soluble in warm water than cold water.	Unit 8: Water and Solution Chemistry	Section A: Water and Its Solutions
C3.5x	Nuclear reactions involve energy changes many times the magnitude of chemical changes. In chemical reactions matter is conserved, but in nuclear reactions a small loss in mass (mass defect) will		

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	account for the tremendous release of energy. The energy released in nuclear reactions can be calculated from the mass defect using $E = mc^2$.		
C3.5a	Explain why matter is not conserved in nuclear reactions.	Unit 10: Nuclear Chemistry	Section C: Conservation of Matter and Energy