Chemistry

Chemistry Standards

The Cobb Teaching and Learning Standards (CT & LS) for science are designed to provide foundational knowledge and skills for all students to develop proficiency in science. The Project 2061's *Benchmarks for Science Literacy* and the follow up work, *A Framework for K-12 Science Education* were used as the core of the standards to determine appropriate content and process skills for students. The Cobb Teaching and Learning Standards focus on a limited number of core disciplinary ideas and crosscutting concepts which build from Kindergarten to high school. The standards are written with the core knowledge to be mastered integrated with the science and engineering practices needed to engage in scientific inquiry and engineering design. Crosscutting concepts are used to make connections across different science disciplines.

The Cobb Teaching and Learning Standards drive instruction. Hands-on, student-centered, and inquiry-based approaches should be the emphasis of instruction. The standards are a required minimum set of expectations that show proficiency in science. However, instruction can extend beyond these minimum expectations to meet student needs.

Science consists of a way of thinking and investigating, as well a growing body of knowledge about the natural world. To become literate in science, students need to possess sufficient understanding of fundamental science content knowledge, the ability to engage in the science and engineering practices, and to use scientific and technological information correctly. Technology should be infused into the curriculum and the safety of the student should always be foremost in instruction.

The Chemistry Teaching and Learning Standards are designed to continue student investigations of the physical sciences that began in grades K-8 and provide students the necessary skills to be proficient in chemistry. These standards include more abstract concepts such as the structure of atoms, structure and properties of matter, the conservation and interaction of energy and matter, and the use of Kinetic Molecular Theory to model atomic and molecular motion in chemical and physical processes. Students investigate chemistry concepts through experiences in laboratories and field work using the process of inquiry. Chemistry students use the periodic table to help with the identification of elements with particular properties, recognize patterns that lead to explain chemical reactivity and bond formation. They use the IUPAC nomenclature in order to predict chemical names for ionic (binary and ternary), acidic, and inorganic covalent compounds, and conduct experiments to manipulate factors that affect chemical reactions.

Unit 1 **3 weeks BL/6 weeks YR**	**Unit 2** **3 weeks BL/6 weeks YR**	**Unit 3** **4 weeks BL/8 weeks YR**	**Unit 4** **3 weeks BL/6 weeks YR**	**Unit 5** **3 weeks BL/6 weeks YR**	**Unit 6** **2 weeks BL/4 weeks YR**
Atomic Structure (SC1)	**Bonding and Compounds (SC2)**	**Reactions (SC3)**	**Thermochemistry and Gas Laws (SC5)**	**Solutions and Acids and Bases (SC6)**	**Reaction Rates and Equilibrium (SC4)**
SC1. **Obtain, evaluate, and communicate information about the use of the modern atomic theory and periodic law to explain the characteristics of atoms and elements.** a. Evaluate merits and limitations of different models of the atom in relation to relative size, charge, and position of protons, neutrons, and electrons in the atom. b. Construct an argument to support the claim that the proton (and not the neutron or electron) defines the element's identity. c. Construct an explanation based on scientific evidence of the production of elements heavier than hydrogen by nuclear fusion. d. Construct an explanation that relates the relative abundance of isotopes of a particular element to the atomic mass of the element. e. Construct an explanation of light emission and the movement of electrons to identify elements. f. 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 (i.e. including atomic radii, ionization energy, and electronegativity). g. Develop and use models, including electron configuration of atoms and ions, to predict an element's chemical properties.	**SC2.** **Obtain, evaluate, and communicate information about the chemical and physical properties of matter resulting from the ability of atoms to form bonds.** a. Plan and carry out an investigation to gather evidence to compare the physical and chemical properties at the macroscopic scale to infer the strength of intermolecular and intramolecular forces. b. Construct an argument by applying principles of inter- and intra- molecular forces to identify substances based on chemical and physical properties. c. Construct an explanation about the importance of molecular-level structure in the functioning of designed materials. d. Develop and use models to evaluate bonding configurations from nonpolar covalent to ionic bonding. (*Clarification statement:* VSEPR theory is not addressed in this element.) e. Ask questions about chemical names to identify patterns in IUPAC nomenclature in order to predict chemical names for ionic (binary and ternary), acidic, and inorganic covalent compounds.	**SC3.** **Obtain, evaluate, and communicate information about how the Law of Conservation of Matter is used to determine chemical composition in compounds and chemical reactions.** a. Use mathematics and computational thinking to balance chemical reactions (i.e., synthesis, decomposition, single replacement, double replacement, and combustion) and construct an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. b. Plan and carry out an investigation to determine that a new chemical has been formed by identifying indicators of a chemical reaction (e.g., precipitate formation, gas evolution, color change, water production, and changes in energy to the system). c. Use mathematics and computational thinking to apply concepts of the mole and Avogadro's number to conceptualize and calculate • percent composition • empirical/molecular formulas • mass, moles, and molecules relationships • molar volumes of gases d. Use mathematics and computational thinking to identify and solve different types of reaction stoichiometry problems (i.e., mass to moles, mass to mass, moles to moles, and percent yield) using significant figures. e. Plan and carry out an investigation to demonstrate the conceptual principle of limiting reactants.	**SC5.** **Obtain, evaluate, and communicate information about the Kinetic Molecular Theory to model atomic and molecular motion in chemical and physical processes.** a. Plan and carry out an investigation to calculate the amount of heat absorbed or released by chemical or physical processes. b. Construct an explanation using a heating curve as evidence of the effects of energy and intermolecular forces on phase changes. c. Develop and use models to quantitatively, conceptually, and graphically represent the relationships between pressure, volume, temperature, and number of moles of a gas.	**SC6.** **Obtain, evaluate, and communicate information about the properties that describe solutions and the nature of acids and bases.** a. Develop a model to illustrate the process of dissolving in terms of solvation versus dissociation. b. Plan and carry out an investigation to evaluate the factors that affect the rate at which a solute dissolves in a specific solvent. c. Use mathematics and computational thinking to evaluate commercial products in terms of their concentrations (i.e., molarity and percent by mass). d. Communicate scientific and technical information on how to prepare and properly label solutions of specified molar concentration. e. Develop and use a model to explain the effects of a solute on boiling point and freezing point. f. Use mathematics and computational thinking to compare, contrast, and evaluate the nature of acids and bases in terms of percent dissociation, hydronium ion concentration, and pH. g. Ask questions to evaluate merits and limitations of the Arrhenius and Bronsted-Lowry models of acid and bases. h. Plan and carry out an investigation to explore acid-base neutralization.	**SC4.** **Obtain, evaluate, and communicate information about how to refine the design of a chemical system by applying engineering principles to manipulate the factors that affect a chemical reaction.** a. Plan and carry out an investigation to provide evidence of the effects of changing concentration, temperature, and pressure on chemical reactions. b. Construct an argument using collision theory and transition state theory to explain the role of activation energy in chemical reactions. c. Construct an explanation of the effects of a catalyst on chemical reactions and apply it to everyday examples. d. Refine the design of a chemical system by altering the conditions that would change forward and amount of products at equilibrium.

SC1. Obtain, evaluate, and communicate information about the use of the modern atomic theory and periodic law to explain the characteristics of atoms and elements.

a. Evaluate merits and limitations of different models of the atom in relation to relative size, charge, and position of protons, neutrons, and electrons in the atom.
b. Construct an argument to support the claim that the proton (and not the neutron or electron) defines the element's identity.
c. Construct an explanation based on scientific evidence of the production of elements heavier than hydrogen by nuclear fusion.
d. Construct an explanation that relates the relative abundance of isotopes of a particular element to the atomic mass of the element.
e. Construct an explanation of light emission and the movement of electrons to identify elements.
f. 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 (i.e. including atomic radii, ionization energy, and electronegativity).
g. Develop and use models, including electron configuration of atoms and ions, to predict an element's chemical properties.

SC2. Obtain, evaluate, and communicate information about the chemical and physical properties of matter resulting from the ability of atoms to form bonds.

a. Plan and carry out an investigation to gather evidence to compare the physical and chemical properties at the macroscopic scale to infer the strength of intermolecular and intramolecular forces.
b. Construct an argument by applying principles of inter- and intra- molecular forces to identify substances based on chemical and physical properties.
c. Construct an explanation about the importance of molecular-level structure in the functioning of designed materials.
(*Clarification statement:* Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.)
d. Develop and use models to evaluate bonding configurations from nonpolar covalent to ionic bonding.
(*Clarification statement:* VSEPR theory is not addressed in this element.)
e. Ask questions about chemical names to identify patterns in IUPAC nomenclature in order to predict chemical names for ionic (binary and ternary), acidic, and inorganic covalent compounds.
f. Develop and use bonding models to predict chemical formulas including ionic (binary and ternary), acidic, and inorganic covalent compounds.
g. Develop a model to illustrate the release or absorption of energy (endothermic or exothermic) from a chemical reaction system depends upon the changes in total bond energy.

SC3. Obtain, evaluate, and communicate information about how the Law of Conservation of Matter is used to determine chemical composition in compounds and chemical reactions.

a. Use mathematics and computational thinking to balance chemical reactions (i.e., synthesis, decomposition, single replacement, double replacement, and combustion) and construct an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
b. Plan and carry out an investigation to determine that a new chemical has been formed by identifying indicators of a chemical reaction (e.g., precipitate formation, gas evolution, color change, water production, and changes in energy to the system).
c. Use mathematics and computational thinking to apply concepts of the mole and Avogadro's number to conceptualize and calculate

- percent composition
- empirical/molecular formulas
- mass, moles, and molecules relationships
- molar volumes of gases

d. Use mathematics and computational thinking to identify and solve different types of reaction stoichiometry problems (i.e., mass to moles, mass to mass, moles to moles, and percent yield) using significant figures.
(*Clarification statement:* For elements c and d emphasis is on use of mole ratios to compare quantities of reactants or products and on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.)
e. Plan and carry out an investigation to demonstrate the conceptual principle of limiting reactants.

SC4. Obtain, evaluate, and communicate information about how to refine the design of a design of a chemical system by applying engineering principles to manipulate the factors that affect a chemical reaction.

a. Plan and carry out an investigation to provide evidence of the effects of changing concentration, temperature, and pressure on chemical reactions.
(*Clarification statement:* Pressure should not be tested experimentally.)
b. Construct an argument using collision theory and transition state theory to explain the role of activation energy in chemical reactions.
(*Clarification statement:* Reaction coordinate diagrams could be used to visualize graphically changes in energy (direction flow and quantity) during the progress of a chemical reaction.)
c. Construct an explanation of the effects of a catalyst on chemical reactions and apply it to everyday examples.
d. Refine the design of a chemical system by altering the conditions that would change forward and reverse reaction rates and the amount of products at equilibrium.
(*Clarification statement:* Emphasis is on the application of LeChatelier's principle.)

SC5. Obtain, evaluate, and communicate information about the Kinetic Molecular Theory to model atomic and molecular motion in chemical and physical processes.

a. Plan and carry out an investigation to calculate the amount of heat absorbed or released by chemical or physical processes.
(*Clarification statement:* Calculation of the enthalpy, heat change, and Hess's Law are addressed in this element.)
b. Construct an explanation using a heating curve as evidence of the effects of energy and intermolecular forces on phase changes.
c. Develop and use models to quantitatively, conceptually, and graphically represent the relationships between pressure, volume, temperature, and number of moles of a gas.

SC6. Obtain, evaluate, and communicate information about the properties that describe solutions and the nature of acids and bases.

a. Develop a model to illustrate the process of dissolving in terms of solvation versus dissociation.
b. Plan and carry out an investigation to evaluate the factors that affect the rate at which a solute dissolves in a specific solvent.
c. Use mathematics and computational thinking to evaluate commercial products in terms of their concentrations (i.e., molarity and percent by mass).
d. Communicate scientific and technical information on how to prepare and properly label solutions of specified molar concentration.
e. Develop and use a model to explain the effects of a solute on boiling point and freezing point.
f. Use mathematics and computational thinking to compare, contrast, and evaluate the nature of acids and bases in terms of percent dissociation, hydronium ion concentration, and pH.
(*Clarification statement:* Understanding of the mathematical relationship between negative logarithm of the hydrogen concentration and pH is not expected in this element. Only a conceptual understanding of pH as related to acid/basic conditions is needed.)
g. Ask questions to evaluate merits and limitations of the Arrhenius and Bronsted-Lowry models of acid and bases.
h. Plan and carry out an investigation to explore acid-base neutralization.