

Chemistry -- Grades 9, 10, 11, 12

California State Science Content Standards

Covered in:

Hands-on science labs, demonstrations, & activities.

Investigation and Experimentation.

Presented by Climate Change Education .org during

Mobile Climate Science Labs

- Professional development for teachers
 - In school presentations
- Climate science and hands-on education *specialists* presenting alongside teachers and teaching assistants
- Presentations at CSTA, NSTA, AAAS conferences
- For school field trips, as presented at local science museums

As aligned with existing science content standards, adopted 1997

Referencing: *Science Framework for California Public Schools*

<http://www.cde.ca.gov/ci/sc/cf/documents/scienceframework.pdf>

Adopted by the California State Board of Education

Published by the California Department of Education

Enabling teachers and schools to provide outstanding education called for in the standards under *Investigation and Experimentation* sections. Requirements for a minimum of 20-25% hands-on education in science.

Index of Standards Alignment—other grades, courses and standards:

http://climatechangeeducation.org/labs/k12_standards/index.html

Themes: <http://climatechangeeducation.org/labs/themes/index.html>

In the following, sections of standards noted are part of one or more lab theme.

Section highlighted in **green** are a *primary focus* of one or more hands-on science lab.

Updated April 27, 2011

Standard Set 1 – Atomic and Molecular Structure

1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:

1. a. *Students know* how to relate the position of an element in the periodic table to its atomic number and atomic mass.
1. b. *Students know* how to use the periodic table to identify metals, semimetals, nonmetals, and halogens.
1. c. *Students know* how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.
1. d. *Students know* how to use the periodic table to determine the number of electrons available for bonding.
1. g.* *Students know* how to relate the position of an element in the periodic table to its quantum electron configuration and to its reactivity with other elements in the table.
1. h.* *Students know* the experimental basis for Thomson's discovery of the electron, Rutherford's nuclear atom, Millikan's oil drop experiment, and Einstein's explanation of the photoelectric effect.
1. i.* *Students know* the experimental basis for the development of the quantum theory of atomic structure and the historical importance of the Bohr model of the atom.
1. j.* *Students know* that **spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Planck's relationship ($E = hv$).**

Standard Set 2 Chemical Bonds

2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:

2. a. *Students know* atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.
2. b. *Students know* **chemical bonds between atoms in molecules such as H_2 , CH_4 , NH_3 , H_2CCH_2 , N_2 , Cl_2** , and many large biological molecules are covalent.

2. g.* *Students know* how electronegativity and ionization energy relate to bond formation.

2. h.* *Students know* how to identify solids and liquids held together by van der Waals forces or hydrogen bonding and relate these forces to volatility and boiling/melting point temperatures.

Standard Set 3 Conservation of Matter and Stoichiometry

3. The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:

3. a. *Students know* how to describe chemical reactions by writing balanced equations.

3. b. *Students know* **the quantity one mole is set by defining one mole of carbon-12 atoms to have a mass of exactly 12 grams.**

3. c. *Students know* one mole equals $6.02 \cdot 10^{23}$ particles (atoms or molecules).

3. d. *Students know* how to determine the molar mass of a molecule from its chemical formula and a table of atomic masses and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.

3. e. *Students know* how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.

3. f.* *Students know* how to calculate percent yield in a chemical reaction.

Standard Set 4 Gases and Their Properties

4. The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:

4. a. *Students know* the **random motion of molecules and their collisions with a surface create the observable pressure on that surface.**

4. b. *Students know* the random motion of molecules explains the diffusion of gases.

4. c. *Students know* **how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.**

4. e. *Students know* **how to convert between the Celsius and Kelvin temperature scales.**

4. f. *Students know* **there is no temperature lower than 0 Kelvin.**

4. g.* *Students know* the **kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.**

4. h.* *Students know* how to solve problems by using the ideal gas law in the form $PV = nRT$.

4. i.* *Students know* how to apply Dalton's law of partial pressures to describe the composition of gases and Graham's law to predict diffusion of gases.

Standard Set 5 Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:

5. a. *Students know* the **observable properties of acids, bases, and salt solutions.**

5. b. *Students know* **acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.**

5. c. *Students know* strong acids and bases fully dissociate and weak acids and bases partially dissociate.

5. d. *Students know* **how to use the pH scale to characterize acid and base solutions.**

5. f.* *Students know* how to calculate pH from the hydrogen-ion concentration.

5. g.* *Students know* **buffers stabilize pH in acid–base reactions.**

Standard Set 6 Solutions

6. Solutions are homogeneous mixtures of two or more substances. As a basis for understanding this concept:

6. a. *Students know* the definitions of *solute* and *solvent*.

6. b. *Students know* how to describe the dissolving process at the molecular level by using the concept of random molecular motion.

6. c. *Students know* **temperature, pressure, and surface area affect the dissolving process.**

6. d. *Students know* how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.

6. f.* *Students know* how molecules in a solution are separated or purified by the methods of chromatography and distillation.

Standard Set 7 Chemical Thermodynamics

7. Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:

7. a. *Students know* **how to describe temperature and heat flow in terms of the motion of molecules (or atoms).**

7. b. *Students know* **chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.**

7. c. *Students know* energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.

7. d. *Students know* **how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.**

Standard Set 8 Reaction Rates

8. Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules. As a basis for understanding this concept:

8. a. *Students know* the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.

8. b. *Students know* **how reaction rates depend on such factors as concentration, temperature, and pressure.**

8. c. *Students know* the role a catalyst plays in increasing the reaction rate.

Standard Set 9 Chemical Equilibrium

9. Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:

9. a. *Students know* how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure.

9. b. *Students know* equilibrium is established when forward and reverse reaction rates are equal.

9. c.* *Students know* how to write and calculate an equilibrium constant expression for a reaction.

Standard Set 10 Organic and Biochemistry

10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life. As a basis for understanding this concept:

10. a. *Students know* large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.

10. b. *Students know* **the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules.**

10. d.* *Students know* the system for naming the ten simplest linear hydrocarbons and isomers that contain single bonds, simple hydrocarbons with double and triple bonds, and simple molecules that contain a benzene ring.

Standard Set 11 Nuclear Processes

11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:

11. a. *Students know* protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.

11. c. *Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.

11. f.* *Students know* **how to calculate the amount of a radioactive substance remaining after an integral number of half-lives have passed.**

End ---- Chemistry Grades 9, 10, 11, 12 --- End