California Science Grades 9–12
Science Contents Standards Mapping

Chemistry	Boardworks High School Chemistry Presentation
<u>Atomic and Molecular Structure</u>	
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:	
1a. Students know how to relate the position of an element in the periodic table to its atomic number and atomic mass.	Atomic Number and Mass Number Introducing Atoms The Periodic Table
1b. Students know how to use the periodic table to identify metals, semimetals, nonmetals, and halogens.	Electron Structure and Periodic Table The Periodic Table
1c. 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.	Electron Structure and Periodic Table Electronegativity Ionization Energy The Periodic Table
1d. Students know how to use the periodic table to determine the number of electrons available for bonding.	Electron Structure and Periodic Table Energy Sublevels Orbitals Patterns of Behavior The Periodic Table
1e. Students know the nucleus of the atom is much smaller than the atom yet contains most of its mass.	Atomic Structure Electron Configuration Introducing Atoms
1f. Students know how to use the periodic table to identify the lanthanide, actinide, and transactinide elements and know that the transuranium elements were synthesized and identified in laboratory experiments through the use of nuclear accelerators.	–
1g.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.	Electron Configuration Energy Sublevels Orbitals Patterns of Behavior The Noble Gases

1h. 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.	Introducing Atoms The Photoelectric Effect
1i. 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.	Introducing Atoms
1j. 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).	Observing Line Spectra
<u>Chemical Bonds</u>	
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:	
2a. Students know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.	Comparing Bonding Covalent Bonding Giant Covalent structures Ionic Bonding Ionic Compounds Metallic Bonding Why do Atoms form Bonds?
2b. Students know chemical bonds between atoms in molecules such as H_2 , CH_4 , NH_3 , H_2 CCH_2 , N_2 , Cl_2, and many large biological molecules are covalent.	Covalent Bonding Polymers
2c. Students know salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.	Ionic Compounds
2d. Students know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.	Intermolecular Forces
2e. Students know how to draw Lewis dot structures.	–
2f. Students know how to predict the shape of simple molecules and their polarity from Lewis dot structures.	–
2g. Students kno*w* how electronegativity and ionization energy relate to bond formation.	Covalent Bonding Electronegativity Ionization Energy
2h. 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.	Intermolecular Forces

<u>Conservation of matter and Stoichiometry</u>	
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:	
3a.Students know how to describe chemical reactions by writing balanced equations.	Conservation of Mass Naming Compounds Reacting Masses
3b. Students know the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.	Molar Mass What are Moles?
3c. Students know one mole equals $6.02x10^{23}$particles (atoms or molecules).	Molar Mass What are Moles?
3d. 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.	Gases and Moles Molar Mass What are Moles?
3e. 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.	Reacting Masses
3f. Students know how to calculate percent yield in a chemical reaction.	The Haber Process Yield and Atom Economy
3g. Students know how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.	Redox Reactions
<u>Gases and their properties</u>	
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:	
4a. Students know the random motion of molecules and their collisions with a surface create the observable pressure on that surface.	Particles in Action
4b. Students know the random motion of molecules explains the diffusion of gases.	Particles in Action
4c. 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.	Ideal Gas Laws
4d . Students know the values and meanings of standard temperature and pressure (STP).	–
4e.Students know how to convert between the Celsius and Kelvin temperature scales.	–
4f. Students know there is no temperature lower than 0 Kelvin.	–

4g. Students know the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.	–
4h. Students know how to solve problems by using the ideal gas law in the form PV = nRT.	Ideal Gas Laws
4i. 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.	–
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:	
5a. Students know the observable properties of acids, bases, and salt solutions.	Neutralization pH and Indicators Properties of Acids and Alkalis
5b.Students know acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.	Formation of ions Neutralization pH and Indicators Properties of Acids and Alkalis
5c. Students know strong acids and bases fully dissociate and weak acids and bases partially dissociate.	Neutralization pH and Indicators Properties of Acids and Alkalis
5d.Students know how to use the pH scale to characterize acid and base solutions.	Neutralization pH and Indicators Properties of Acids and Alkalis
5e. Students know the Arrhenius, Brønsted-Lowry, and Lewis acid-base definitions.	–
5f. Students know how to calculate pH from the hydrogen-ion concentration.	–
5g. Students know buffers stabilize pH in acid-base reactions.	–
Solutions	
6. Solutions are homogeneous mixtures of two or more substances. As a basis for understanding this concept:	
6a. Students know the definitions of solute and solvent.	Solutions Solubility
6b. Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.	Particles in Action Solutions
6c. Students know temperature, pressure, and surface area affect the dissolving process.	Solutions Solubility

6d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.	Percentage Composition by Mass
6e. Students know the relationship between the molality of a solute in a solution and the solution's depressed freezing point or elevated boiling point.	–
6f. Students know how molecules in a solution are separated or purified by the methods of chromatography and distillation.	Separating Mixtures
Chemical Thermodynamics	
7. Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:	
7a. Students know how to describe temperature and heat flow in terms of the motion of molecules (or atoms).	Temperature and Reaction Rates
7b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.	Combustion Equilibrium - Changing Conditions Endothermic Reactions Exothermic Reactions
7c. Students know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.	Thermal Decomposition
7d. Students kno*w* how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.	Calorimetry
7e. Students know how to apply Hess's law to calculate enthalpy change in a reaction.	Enthalpy Change
7f. Students know how to use the Gibbs free energy equation to determine whether a reaction would be spontaneous.	–
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:	
8a. Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.	Rates of Reaction
8b. Students know how reaction rates depend on such factors as concentration, temperature, and pressure.	Temperature and Reaction Rates
8c. Students know the role a catalyst plays in increasing the reaction rate.	Surface Area, Catalysts and Reaction Rates
8d. Students know the definition and role of activation energy in a chemical reaction.	Bonds and Activation Energy
Chemical Equilibrium	
9. Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:	

9a. Students know how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure.	Dynamic Equilibrium Equilibrium - Changing Conditions Le Chatelier's Principle Temperature and Reaction Rates
9b. Students know equilibrium is established when forward and reverse reaction rates are equal.	Dynamic Equilibrium Le Chatelier's Principle Reversible Reactions
9c. Students know how to write and calculate an equilibrium constant expression for a reaction.	–
Organic Chemistry	
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:	
10a. Students know large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.	Hydrogenation Nucleic Acids Polymers Polysaccharides
10b. 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.	Hydrogenation Polymers
10c. Students know amino acids are the building blocks of proteins.	Proteins
10d. 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.	Hydrocarbons Isomers
10e. Students know how to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.	Alcohols Carboxylic Acids Esters Functional Groups
10f. Students know the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins.	Proteins
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:	
11a. Students know protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.	Radioactivity

11b. Students know the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by $E = mc^2$) is small but significant in nuclear reactions.	Chain Reactions Nuclear Fission Nuclear Fusion
11c. Students know some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.	Half-life Isotopes
11d. Students know the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.	Gamma Rays Radioactivity Types of Radiation
11e. Students know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.	Dangers of Radiation Gamma Rays Nuclear Waste Radioactivity Types of Radiation Uses of Radiation
11f. Students know how to calculate the amount of a radioactive substance remaining after an integral number of half-lives have passed.	Half-life Radioactive Dating
11g. Students know protons and neutrons have substructures and consist of particles called quarks.	–