CHEMISTRY

Introduction

Ninth to Twelfth Grades ILOs

The purpose of the Utah Chemistry Core Curriculum is to provide the standards for ALL students to achieve basic scientific literacy in chemistry. Project 2061's Benchmark's For Science Literacy and The National Science Education Standards were used as guides to determine appropriate content and process skills for students, with an emphasis on inquiry. The core is written with the understanding that individual teachers will choose additional content and activities to meet the needs and interests of their own students.

The Intended Learning Outcomes (ILOs) are to be used as a guide for selecting instructional strategies. In designing instruction, teachers should build upon the natural inquisitiveness of students and emphasize inquiry as the way in which students grasp science knowledge and investigate the world. The Chemistry Core Curriculum should be routinely linked to a student's everyday experience and to relevant current events.

The hands-on nature of the Core Objectives increases the need for teachers to use appropriate precautions in the laboratory. It is recommended that teachers use microchemistry techniques where appropriate. The guidelines for the safe use, storage, and disposal of chemicals must be observed.

CHEMISTRY

Science Benchmark

Matter in the universe is made of atoms that have structure, mass and a common origin. Atoms are so small that a million atoms placed side by side are no wider than a period on this page. The nucleus of an atom is a tiny fraction of the volume of the atom. Each proton or neutron in the nucleus is nearly 2000 times the mass of an electron. Electrons move around the nucleus. The modern atomic model has been developed using experimental evidence.

A balance is the most practical way to measure a small quantity of matter. Particles too small to be seen may be counted using the relationship between the enormous number of atoms in a mole and the mass of those atoms.

The periodic table is used to organize elements by structure. A relationship exists between the chemical behavior and the structure of atoms. The periodic table reflects this relationship.

Atomic theories describe the behavior of atoms as well as energy changes in the atom. Energy changes in an isolated atom occur only in discrete jumps. Changes in structure and composition of the nucleus result in the conversion of matter into energy.

STANDARD I: Students will understand that matter in the universe is made of atoms that have structure and are represented systematically in the periodic table.

Objective 1: Identify the origin of matter in the universe and describe the historical development of atomic models that have led to today's understanding of the atom.

a. Identify evidence supporting the assumption that matter in the universe has a common origin and is composed of the same elements found on Earth.
b. Summarize the major experimental evidence that led to the development of various atomic models, both historical and current.

c. Evaluate the limitations of using models to describe atoms.

Objective 2: Relate the structure and scale of an atom to the particles that compose it.

a. Compare protons, neutrons and electrons using relative size, charge and position in the atom.
b. Generalize the relationship of proton number to element.
c. Using the mole, compare the size of atoms to gram sized quantities of matter.

Objective 3: Correlate atomic structure and the physical and chemical properties of an element to the position of the element on the periodic table.

a. Use the periodic table to determine the number of protons, neutrons, and electrons in an atom.
b. Compare the number of protons and neutrons in isotopes of the same element.
c. Identify similarities in chemical behavior of elements in a group.
d. Generalize trends in the reactivity of elements within a group to trends in other groups.
e. Compare the properties of elements (i.e., metal, nonmetallic, metalloid) based on their position in the periodic table.

Science language students should use:
Atom, element, molecule, allotrope, nucleus, proton, neutron, electron, isotope, metalloid, metal, non-metal, reactivity, periodic table, group, period.

STANDARD II: Students will understand that the relationship between the transition of electrons to different energy levels in an atom and the emission or absorption of energy, and that the emission of high-energy radiation results from nuclear changes and that matter can be converted to energy in nuclear reactions.

Objective 1: Identify how the quantum energy changes in the atom in terms of light emission.

a. Identify the relationship between energy and wavelength of light.
b. Correlate the energy in a photon to the color of light emitted.
c. Collect and examine evidence from the lab indicating that energy is absorbed or released in discrete quanta when electrons move from one energy level to another.
d. Apply the concept of distinctive light energies emitted or absorbed by different atoms to the identification (e.g., flame test, spectrum tubes) of these atoms on earth on our sun, or elsewhere in the universe.

Objective 2: Evaluate how changes in the nucleus of an atom result in emission of energy in the form of radioactivity.

a. Compare the stability of nuclei of radioactive isotopes to the nuclei of stable isotopes (e.g., radioactive isotopes spontaneously decay and emitting particles and/or wavelike radiation stable isotopes do not).
b. Relate the strength of the nuclear force to the strength of the electromagnetic force in chemical bonds.
c. Compare the relatively small energy changes in chemical reactions to the relatively large energy changes in nuclear reactions.
d. Identify relative changes in nuclear mass in the processes of fission and fusion.
e. Interpret graphical data relating half-life and age of a radioactive substance.

f. After researching, evaluate and report the effects of nuclear radiation on humans or other organisms.

Science language students should use:
Atom, element, nucleus, proton, neutron, electron, metalloid, periodic table, isotope, metal, half-life, fission, fusion, nonmetal, quanta, photon, wavelength, radioactivity, spectrum

Science Benchmark

Atoms form bonds with other atoms by transferring or sharing electrons. The formation of compounds results in a great diversity of matter from a limited number of elements. Writing the chemical formula for a compound is one way to describe the compound. The electron configuration of an atom, particularly the valence electrons, determines how an atom can interact with other atoms. Many of the physical properties of compounds are determined by the type of chemical bonds holding them together. The strength and type of intermolecular forces also affect the physical properties of a compound.

STANDARD III: Students will understand that all matter, with very different properties, is made from relatively few elements.

Objective 1: Explain that compounds are made from a limited number of elements and can be represented using combinations of symbols indicating the number and kinds of atoms in a molecule.

a. Use a chemical formula to represent the elements and the number of each element in a compound.
b. Identify that a large number of compounds can be made from a limited number of elements.
c. Explain that a formula representing a compound is unique to that compound.

Objective 2: Compare the properties of a compound to the properties of the elements from which it is formed.

a. Using examples compare specific physical properties of a compound to the properties of elements from which it was formed (e.g., Sodium Chloride solid- Chlorine gas)
b. Using examples compare specific chemical properties of a compound to the properties of elements from which it was formed (e.g., sodium reacts vigorously with water - salt dissolves and ionizes in water).
c. Explain that combining elements in different proportions results in the formation of different compounds with different properties.

Science language students should use:
Compound, ionic compound, ion, anion, cation, polyatomic ion, electroneutrality, octet rule, ionic bond

STANDARD IV: Students will understand chemical bonding and the relationship of the type of bonding to the chemical and physical properties of substances.

Objective 1: Analyze the relationship between the valence (outermost) electrons of an atom and the type of bond formed between atoms.

a. Determine the number of valence electrons in atoms using the periodic table.

b. Using the periodic table, predict the charge an atom will acquire when it forms an ion by gaining or losing electrons.
c. Compare covalent and ionic bonds with respect to electron behavior and relative bond strengths.
d. Diagram a model of a metallic bond and explain how it differs from ionic and covalent bonds.

Objective 2: Use Valence shell electron pair repulsion theory (VESPR) to determine the geometry of covalent compounds.

a. Using Lewis structures determine the number of bonding pair electrons and nonbonding pair electrons in simple covalent compounds such as ammonia, water, and methane.
b. Using the bonding versus nonbonding electron pairs and VESPR determine the shape of simple covalent compounds such as ammonia, water and methane.

Objective 3: Relate the physical properties of simple compounds to the type of bonding between their atoms and to the intermolecular forces between molecules.

a. Generalize, from observation in the lab, the physical properties (e.g., malleability, conductivity and solubility) of substances with different bond types.
b. Using models, relate the shape and resulting polarity of water, ammonia, and methane molecules to physical properties of these compounds.
c. Identify how intermolecular forces of ”hydrogen bonding” in water affect a variety of physical and biological phenomena (e.g. surface tension, capillary action, boiling point).

Science language students should use:
Covalent bond, electronegativity, bond strength, metallic bond, VESPR, Lewis structures, bonding electrons, nonbonding electrons, physical properties, chemical properties, intermolecular force, intramolecular force, dipole

Science Benchmark

Solutions make up many of the ordinary substances encountered in everyday life. The rate at which a solute dissolves is determined by a variety of factors. The relative amounts of solutes and solvent determine the concentration and the physical properties of a solution. Dissolved acids and bases make up two important categories of solutions.

STANDARD V: Students will understand that solutions are made from solutes and solvents, and their concentration can be expressed in a variety of ways.

Objective 1: Analyze factors affecting the process of dissolving and identify the parts of a solution.

a. Use the terms solute and solvent in describing a solution.
b. Sketch a solution at the particle level.
c. Design and conduct an experiment to determine the factors (e.g., agitation, particle size, temperature) affecting the relative rate of dissolution.

Objective 2: Calculate the concentration of a solution in terms of molarity, percent concentration, and parts per million and relate concentration levels to specific applications.

a. Compare the amount of solute particles in concentrated and dilute molar solutions.
b. Determine the concentration of a solution that is given in terms of the grams of solute and liters of solution.

c. Relate the concentration of a solution to a specific use of the solution (e.g., concentration of sugar in punch, concentration of sulfuric acid in a car battery, concentration of active ingredients in a medicine).
d. Explain concepts of dilution and scale, and infer implications for environmental pollutants.
e. Relate the concept of parts per million (PPM) to a relevant environmental issue.
f. Measure and compare changes of boiling and/or freezing point of a solvent when a solute is added.

Objective 3: Differentiate between acids and bases in terms of hydrogen ion concentration.

a. Relate hydrogen ion concentration to pH values and to the terms acidic, basic or neutral.
b. Using an indicator, measure the pH of common household or standard laboratory solutions and identify them as acids and bases.
c. Use a simple acid-base titration to determine the concentration of an acid or a base.
d. Research and report on the uses of acids and bases in industry, agriculture, medicine, mining, manufacturing, or construction.
e. Evaluate mechanisms by which pollutants modify the pH of various environments (e.g., aquatic, atmospheric, soil.)

Science language students should use:
solution, solute, solvent, concentration, molarity, percent concentration, parts per million, concentrated, dilute, colligative property, boiling point, freezing point, acid, base, pH, pOH, indicator, hydrogen ion, hydroxide ion, neutralization

Science Benchmark

In a chemical reaction new substances are formed as atoms and molecules are rearranged. The concept of atoms accounts for the conservation of mass since the number of atoms stays the same in a chemical reaction.
Energy can be absorbed or released in a chemical reaction, but the total amount of energy remains constant. The rate of reactions among atoms and molecules depends upon how often they encounter one another. Concentration, temperature, and pressure of the reacting materials affect the frequency of encounters. Catalysts can be used to change the rate of reaction. Many reactions attain a state of equilibrium. Many ordinary activities, such as baking, involve chemical reactions.

STANDARD VI: Students will understand that in chemical reactions matter and energy change, but the amounts of matter and energy do not change.

Objective 1: Identify evidence of chemical reactions and demonstrate how chemical equations are used to describe chemical reactions.

a. Generalize evidences of chemical reactions.
b. Compare the properties of reactants to the properties of products in a chemical reaction.
c. Investigate everyday chemical reactions that occur in a student's home (e.g. baking, rusting, bleaching, cleaning).

Objective 2: Demonstrate the law of conservation of mass in a chemical reaction.

a. Using data from quantitative analysis, support the conservation of mass in a chemical reaction.
b. Determine molar ratios of reactants and products in a chemical reaction.
c. Demonstrate the law of conservation of mass with a balanced chemical equation.

d. Recognize that the number of atoms in a chemical reaction does not change.

Objective 3: Describe evidence that supports the law of conservation of energy in a chemical reaction.

a. Recognize that heat energy in a material, measured as temperature, consists of the random motion of its atoms or molecules.
b. After observing or measuring temperature change in a reaction, classify the reaction as endothermic or exothermic.
c. Trace the transfer of energy from one form to another in a chemical reaction (e.g. chemical energy may become heat energy, light energy, electrical energy).
d. Use either a constructed or a diagramed electrochemical cell to describe how chemical energy can produce electrical energy in a chemical reaction.

Objective 4: Students will use the kinetic-molecular theory of energy to describe the behavior of gases.

a. Use Kinetic-molecular theory to verify Boyle's Law and Charles' Law.
b. Use the Ideal Gas Law to describe the effects of pressure, volume, moles, and temperature of an 'ideal' gas.

STANDARD VII: Students will understand factors that influence chemical reactions and that some reactions can achieve a state of dynamic equilibrium.

Objective 1: Evaluate factors specific to collisions (e.g. temperature, particle size, and concentration) that affect the rate of chemical reaction.

a. Correlate frequency and energy of collisions to reaction rate.
b. Use information from graphs to draw warranted conclusions about reaction rates.
c. Describe the effects of catalysts on reaction rates.
d. After designing, conducting, and reporting an investigation of a factor affecting reaction rate, generalize the results to other reactions.

Objective 2: Demonstrate that certain reactions do not convert all reactants to products, but achieve a state of dynamic equilibrium that can be changed.

a. Explain the concept of dynamic equilibrium.
b. Given an equation, identify the effect of adding either product or reactant to a shift in equilibrium.
c. Indicate the effect of a temperature change on the equilibrium, using an equation showing a heat term.

Science language students should use:
chemical reaction, matter, Law of Conservation of Mass, Law of Conservation of Energy, temperature, electrochemical cell, rate, catalyst, concentration, equilibrium, chemical equation, endothermic, exothermic, heat, specific heat, reactants, products, activation energy, oxidation-reduction reactions, spontaneous reaction.