

## STANDARD 1: SCIENCE AS INQUIRY (Chemistry) Twelfth Grade

**As a result of their activities in grades 9-12, all students will develop the abilities necessary to do scientific inquiry and develop an understanding of scientific inquiry.**

**Benchmark 1: Students will demonstrate the abilities necessary to do scientific inquiry.**

The student...

1. develops an understanding of the natural world through experience in order to ask and evaluate research questions.
2. ▲ identifies and utilizes concepts that guide scientific investigations, including developing questions, gathering data, and design and conducting research.

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- a. formulating a testable hypothesis
- b. utilizing variables, such as independent, dependent, and controls
- c. determining methods for gathering data that is observable, measurable, and replicable
- d. using statistical and graphing data analysis techniques
- e. evaluating the results in order to clarify the questions and hypotheses, and to refine methods for further research.

To develop these skills, students might be involved in such activities as: change of phase experiments; gas collection and measurement; analyzing compounds; re-dox experiments; acid-base titrations; molar mass determination.

3. ▲ uses technological tools and mathematics in scientific investigations.

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- a. uses a variety of technologies, such as hand tools, measuring instruments, calculators, and computers as an integral component of scientific investigations.
  - b. uses common mathematical functions (linear, exponential, etc.) to analyze and describe data
  - c. recognizes that the accuracy and precision of the data, and therefore the quality of the investigation, depends on the instruments used.
  - d. uses equipment properly and safely.
4. ▲ as part of conducting an inquiry, formulates and revises his or her scientific explanations and models (physical, conceptual, or mathematical) using logic and evidence, recognizing that potential alternative explanations and models should be considered.

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- a. engages in discussions that result in the revision of his/her explanation.
  - b. analyzes their explanation by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models have the greatest explanatory power.
  - c. evaluates personal preconceptions and biases with respect to his/her conclusions.
5. communicates and defends the design, results, and conclusion of his/her investigation.

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- a. writes procedures, expresses concepts, reviews information, summarizes data, and uses language appropriately, develops diagrams and charts to summarize and analyze data.
- b. presents information clearly and logically, both orally and in writing
- c. constructs reasoned arguments
- d. responds appropriately to critical comments.

## **STANDARD 2A: CHEMISTRY**

### **Twelfth Grade**

**As a result of their activities in grades 9-12, all students will develop an understanding of the structure of atoms, *compounds*, chemical reactions, and the interactions of energy and matter.**

**Benchmark 1: The student will understand the structure of the atom.**

1. ▲ Atoms, the fundamental organizational unit of matter, are composed of subatomic particles, organized in a small, dense, positively charged nucleus (containing protons and neutrons which determines the atomic mass) and surrounded by a negatively charged electron cloud (containing electrons, which determines the size of the atom).

*USD 312 Students Will be able to*

- a. name the common elements, their symbols and their common oxidation numbers
- b. demonstrate the use of units needed for chemistry
- c. perform density calculations
- d. determine the number of protons, neutrons, and electrons in a nuclide, given the identity of the nuclide
- e. calculate problems using the mole ratio

- f. diagram any atom using the quantum numbers
  - g. describe the arrangement of electrons around the atoms of any element using orbital notation, electron configuration or electron-dot notation
  - h. write Lewis structures for a molecule or polyatomic ions
  - i. diagram covalent and ionic compounds using the four quantum numbers
  - j. determine the formula of an ionic compound between any two given ions
  - k. name an ionic compound given its formula
  - l. using prefixes, name a binary molecular compound from its formula
  - m. write the formula of a binary molecular compound, given its name
2. Isotopes are atoms with the same atomic number (same number of protons) but different numbers of neutrons. The nuclei of some atoms are radioactive isotopes that spontaneously release radioactive energy.

**Benchmark 2: The students will understand the states and properties of matter.**

1. Chemists use kinetic and potential energy to explain the physical and chemical properties of matter on earth that may exist in any of these three states; solids, liquids, and gases.

*USD 312 Students Will be able to*

- a. using the ideal-gas law, calculate one of the quantities - pressure, volume, temperature, amount of gas when the other three are known
- b. using the ideal gas law, calculate the molar mass or density of a gas.
- c. use volume ratios, standard molar volume, and the gas laws where appropriate to calculate volumes, masses, or molar amounts of reactants or products in reactions involving gases
- d. compare the effect of temperature and pressure on solubility
- e. given the concentration of a solution, find the amount of solute in a given amount of solution
- f. given the concentration of a solution, find the amount of solution that contains a given amount of solute
- g. given the appropriate information, calculate freezing-point depression, boiling-point elevation, or solution in molarity.
- h. calculate molar mass from freezing-point depression or boiling-point elevation data
- i. solve problems involving heats of reaction, heats of formation, and heats of combustion
- j. balance redox equations by using the oxidation-number method
- k. balance redox equations by using the ion-electron method
- l. calculate potential voltage of redox equations

- m. elements and molecules may exist as gasses, liquids or solids; Ionic compounds most commonly exist as solids.
  - n. Intermolecular attraction (attraction between molecules) determines the state of the molecule. Gases have the weakest and solids have the greatest intermolecular attraction. The hydrogen bond is an intermolecular attraction responsible for the properties of water and many biological molecules.
2. ▲ The periodic table lists elements according to increasing atomic number. This table organizes physical and chemical trends by groups, periods, and categories.

*USD 312 Students Will be able to*

- a. name the common elements, their symbols and their common oxidation numbers
  - b. demonstrate the use of units needed for chemistry
  - c. perform density calculations
  - d. determine the number of protons, neutrons, and electrons in a nuclide, given the identity of the nuclide
  - e. calculate problems using the mole ratio
  - f. diagram any atom using the quantum numbers
  - g. describe the arrangement of electrons around the atoms of any element using orbital notation, electron configuration or electron-dot notation
  - h. elements in the same group share similar chemical properties because they have the same number of valence electrons. Periods indicate the energy level of the outermost (*valence*) electrons. Some categories are regions such as metals, non-metals, and transition elements.
  - i. There are discrete energy levels for electrons in an atom. Electrons changing from one energy level to another may result in the emission or absorption of various forms of electromagnetic radiation, including the range of colors that form visible light. Indeed, when there is color, there are electrons changing energy levels.
3. ▲ Chemical bonds result when valence electrons are transferred or shared between atoms. Ionic compounds result from atoms transferring electrons. Molecular compounds result from atoms sharing electrons.

*USD 312 Students Will be able to*

- a. write Lewis structures for a molecule or polyatomic ions
- b. diagram covalent and ionic compounds using the four quantum numbers
- c. determine the formula of an ionic compound between any two given ions
- d. name an ionic compound given its formula
- e. using prefixes, name a binary molecular compound from its formula

- f. write the formula of a binary molecular compound, given its name
- g. list the names and formulas of the common laboratory acids
- h. calculate the formula mass or molar mass of any given compound
- i. use molar mass to convert between mass in grams and amount in moles of a chemical compound
- j. give the number of molecules, formula units or ions in a given molar amount of a chemical compound
- k. calculate the percent composition of a given chemical compound
- l. find a simplest formula from either percent or mass composition
- m. Valence electrons (those farthest from the nucleus or highest energy electrons) determine the chemistry of the atom
- n. Ionic compounds are composed of (positively charged) metal cations and (negatively charged) nonmetal anions
- o. Molecules result when two or more nonmetals share electrons (form a covalent bond).

**Benchmark 3: The students will gain a basic concept of chemical reactions.**

1. ▲ A chemical reaction occurs when one or more substances (reactants) react to form a different chemical substance(s) (products). There are different types of chemical reactions that demonstrate the Law of Conservation of Mass i.e., synthesis, decomposition, combustion, single and double replacement, acid/base, and oxidation/reduction.

*USD 312 Students Will be able to*

- a. write a word equation and a formula equation, given a description of a chemical reaction
- b. balance a formula equation by inspection
- c. define mole ratio and describe its role in stoichiometry calculations
- d. describe the method for determining which of two reactants is a limiting reactant
- e. calculate the amount in moles or mass of a product, given the amounts in moles or masses of two reactants, one of which is in excess
- f. calculate percent yield, given actual yield and quantity of reactant
- g. calculate gas problems, using the combined gas laws
- h. calculate the molar mass and density of a gas by using standard molar volume
- i. write the equation for the reactions of acid anhydrides and basic anhydride with water
- j. find the number of equivalence and the equivalent mass for a given acid or base in an acid/base reaction
- k. calculate solution normality from solution concentration for a given acid or base
- l. given  $(\text{H}_3\text{O}^+)$  or  $(\text{OH}^-)$ , find pH
- m. given pH, find  $(\text{H}_3\text{O}^+)$  or  $(\text{OH}^-)$

- n. calculate the molarity of a solution from titration data
- o. calculate the normality of a solution from titration data
- p. chemical reactions are written as chemical equations, which demonstrate the Law of Conservation of Mass through stoichiometric relationships
- q. two or more of the following may often identify chemical reactions: physical property change, effervescence, mass change, precipitation, light emission, and heat exchange
- r. heat exchange during a chemical reaction is often easily noticed: a reaction that absorbs heat will feel colder; a reaction that releases heat will feel warmer
- s. the tendency of nature to occupy the greatest number of different states, called entropy, is ultimately the driving force behind chemical reactions
- t. the rate (speed) of a chemical reaction depends on such parameters as temperature, concentration, catalysts, and reaction type