

# INDIANA STATE SCIENCE STANDARDS

*Approved 03.29.10*

## Chemistry I

Students should understand that scientific knowledge is gained from observation of natural phenomena and experimentation, by designing and conducting investigations guided by theory, and by evaluating and communicating the results of those investigations according to accepted procedures. Thus, scientific knowledge is scientists' best explanations for the data from many investigations. Further, ideas about objects in the microscopic world that we cannot directly sense are often understood in terms of concepts developed to understand objects in the macroscopic world that we can see and touch. In the science classroom student work should align with this process of science and should be guided by the following principles. These should be woven throughout the daily work that students are doing when learning the content presented in the standard indicators.

- Develop explanations based on reproducible data and observations gathered during laboratory investigations.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Clearly communicate their ideas and results of investigations verbally and in written form using tables, graphs, diagrams, and photographs.
- Regularly evaluate the work of their peers and in turn have their work evaluated by their peers.
- Apply standard techniques in laboratory investigations to measure physical quantities in appropriate units and convert known quantities to other units as necessary.
- Use analogies and models (mathematical and physical) to simplify and represent systems that are difficult to understand or directly experience due to their size, time scale, or complexity, and recognize the limitations of analogies and models.
- Focus on the development of explanatory models based on their observations during laboratory investigations.
- Explain that the body of scientific knowledge is organized into major theories, which are derived from and supported by the results of many experiments, and allow us to make testable predictions.
- Recognize that new scientific discoveries often lead to a re-evaluation of previously accepted scientific knowledge and of commonly held ideas.

- Describe how scientific discoveries lead to the development of new technologies, and conversely how technological advances can lead to scientific discoveries through new experimental methods and equipment.
- Explain how scientific knowledge can be used to guide decisions on environmental and social issues.

## **Standard 1: Properties and States of Matter**

### ***Core Standard***

**Describe the nature of physical and chemical properties and changes of matter.**

**CHAPTER 3**

### ***Core Standard***

**Compare and contrast states of matter at the molecular level. CHAPTER 4**

C.1.1 Based on physical properties, differentiate between pure substances and mixtures.

C.1.2 Observe and describe chemical and physical properties of different types of matter and designate them as either extensive or intensive.

C.1.3 Recognize observable indicators of chemical changes.

C.1.4 Describe physical and chemical changes at the molecular level.

C.1.5 Describe the characteristics of solids, liquids, and gases and state changes at the molecular level.

C.1.6 Explain and apply the law of conservation of mass as it applies to chemical processes.

C.1.7 Define density and distinguish among materials based on densities. Perform calculations involving density.

## **Standard 2: Atomic Structure and the Periodic Table**

### ***Core Standard***

**Describe how the properties and arrangement of the subatomic particles contributes to the structure of the atom. CHAPTER 4 & 5**

### ***Core Standard***

**Describe how the structure of the periodic table reflects the numbers of electrons and protons and the configuration of the electrons in an atom. CHAPTER 6**

C.2.1 Describe how models of atomic structure changed over time based on available

experimental evidence and understand the current model of atomic structure.

C.2.2 Describe how the subatomic particles (protons, neutrons, and electrons) contribute to the structure of an atom and recognize that the particles within the nucleus are held together against the electrical repulsion of the protons.

C.2.3 Determine the number of protons, neutrons, and electrons in isotopes and in those isotopes that comprise a specific element. Relate these numbers to atomic number and mass number.

C.2.4 Calculate the average atomic mass of an element from isotopic abundance data.

C.2.5 Write the electron configuration of an element and relate this to its position on the periodic table.

C.2.6 Use the periodic table and electron configurations to determine an element's number of valence electrons, and chemical and physical properties.

C.2.7 Compare and contrast nuclear reactions with chemical reactions. For nuclear reactions, describe how the fusion and fission processes transform elements present before the reaction into elements present after the reaction.

C.2.8 Understand that the radioactive decay process is random for any given atom, but that this property leads to a predictable and measurable exponential decay of a sample of radioactive material. Calculate the initial amount, the fraction remaining, or the half-life of a radioactive isotope, given two of the three variables.

## **Standard 3: Bonding and Molecular Structure**

### ***Core Standard***

**Describe how the configuration of electrons within an atom determines its interactions with other atoms. CHAPTER 5**

### ***Core Standard***

**Describe the attractive forces between molecules and how their effect on chemical and physical properties. CHAPTER 8 & 9**

C.3.1 Describe, compare, and contrast the characteristics of the interactions between atoms in ionic and covalent compounds.

C.3.2 Compare and contrast how ionic and covalent compounds form.

C.3.3 Compare and contrast ionic, covalent network, metallic and polar and non-polar molecular crystals with respect to constituent particles, strength of bonds, melting and boiling points and conductivity; provide examples of each type.

C.3.4 Draw structural formulas for and name simple molecules.

C.3.5 Write chemical formulas for ionic compounds given their names and vice versa.

## **Standard 4: Reactions and Stoichiometry**

### ***Core Standard***

**Use balanced chemical equations and the mole concept to determine the quantities of reactants and products. CHAPTER 10 & 12**

C.4.1 Predict products of simple reactions such as synthesis, decomposition, single replacement and double replacement.

C.4.2 Balance chemical equations using the law of conservation of mass and use them to describe chemical reactions.

C.4.3 Use the mole concept to determine the number of moles and number of atoms or molecules in samples of elements and compounds, given mass of the sample.

C.4.4 Using a balanced chemical equation, calculate the quantities of reactants needed and products made in a chemical reaction that goes to completion.

C.4.5 Describe, classify and give examples of various kinds of reactions-synthesis (combination), decomposition, single displacement, double displacement and combustion.

C.4.6 Determine oxidation states and identify the substances apparently gaining and losing electrons in redox reactions.

C.4.7 Perform calculations to determine percent composition by mass of a compound or mixture when given the formula.

## **Standard 5: Behavior of Gases**

### ***Core Standard***

**Using the kinetic molecular theory, describe and explain the behavior of ideal gases. CHAPTER 14**

### ***Core Standard***

**Examine the relationship between number of moles, volume, pressure, and temperature for ideal gases, using the ideal gas equation of state  $PV = nRT$ . CHAPTER 14**

C.5.1 Use kinetic molecular theory to explain changes in gas volumes, pressure, moles, and temperature.

C.5.2 Using the ideal gas equation of state,  $PV = nRT$ , calculate the change in one variable when another variable is changed and the others are held constant.

C.5.3 Given the equation for a chemical reaction involving one or more gases as reactants and/or products calculate the volumes of gas assuming the reaction goes to completion and the ideal gas law holds.

## **Standard 6: Thermochemistry**

### ***Core Standard***

**Recognize that chemical reactions result in either the release or absorption of energy. CHAPTER 16**

### ***Core Standard***

**Apply the law of conservation of energy. CHAPTER 16**

C.6.1 Explain that atoms and molecules that make up matter are in constant motion and that this motion increases as thermal energy increases.

C.6.2 Distinguish between the concepts of temperature and heat flow in macroscopic and microscopic terms.

C.6.3 Solve problems involving heat flow and temperature changes, using known values of specific heat and/or phase change constants (latent heat values).

C.6.4 Classify chemical reactions and phase changes as exothermic or endothermic.

## **Standard 7: Solutions**

### ***Core Standard***

**Describe the composition and characteristics of solutions. CHAPTER 15**

### ***Core Standard***

**Identify the factors that qualitatively affect solubility, reaction rates and dynamic equilibrium. CHAPTER 15 & 18**

C.7.1 Describe the composition and properties of types of solutions.

C.7.2 Explain how temperature, pressure and polarity of the solvent affect the solubility of a solute.

C.7.3 Describe the concentration of solutes in solution in terms of molarity. Perform calculations using molarity, mass, and volume.

C.7.4 Prepare a specific volume of a solution of a given molarity when provided with a known solute.

C.7.5 Explain how the rate of a reaction is qualitatively affected by changes in concentration, temperature, surface area, and the use of a catalyst.

C.7.6 Write equilibrium expressions for reversible reactions.

## **Standard 8: Acids and Bases**

### ***Core Standard***

**Use acid-base definitions to identify acids and bases given their formulas and reactions. CHAPTER 19**

### ***Core Standard***

**Explain the meaning of the value indicated by the pH scale in terms of the hydrogen ion concentration for any aqueous solution. CHAPTER 19**

C.8.1 Use Arrhenius and Brønsted-Lowry definitions to classify substances as acids or bases.

C.8.2 Describe the characteristic properties of acids and bases.

C.8.3 Compare and contrast the dissociation and strength of acids and bases in solution.

C.8.4 Given the hydronium ( $\text{H}_3\text{O}^+$ ) ion concentration in a solution, calculate the pH, and vice versa. Explain the meaning of these values.

C.8.5 From acid-base titration data, calculate the concentration of an unknown solution.

## **Standard 9: Organic Chemistry and Biochemistry**

### ***Core Standard***

**Describe the unique nature of carbon atoms demonstrated by their ability to bond to one another and other elements, forming countless carbon-based substances and macromolecules. CHAPTER 22**

C.9.1 Use structural formulas to illustrate carbon atoms' ability to bond covalently to one another to form many different substances.

C.9.2 Illustrate the variety of molecular types formed by the covalent bonding of carbon atoms and describe the typical properties of these molecular types.