BALANCING CHEMICAL EQUATIONS

Practice Worksheets

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INTRODUCTION

This chemistry resource offers instruction and practice balancing chemical reactions:

- Examples are fully solved to help serve as a guide.
- The first chapter introduces relevant terminology, such as the meaning of reactants, products, and chemical change.
- Chapter 2 focuses on counting atoms with subscripts and parentheses.
- Chapter 3 discusses the concept of balancing equations and outlines a strategy for determining the coefficients.
- Chapter 4 begins with chemical reactions that involve only two elements. These simpler problems let students get the hang of it before tackling more difficult problems.
- Chapter 5 involves reactions with three elements, Chapter 6 involves reactions with four elements, and the problems are more challenging in Chapter 7. This progressive organization helps students learn the art of balancing reactions one stage at a time.
- The answer key includes the answer to every problem.

1 Terminology

When the composition of a substance changes form (based on how the atoms are joined together), a **chemical change** occurs.

An example of a chemical change occurs in photosynthesis where carbon dioxide (CO_2) and water (H_2O) molecules react together to form glucose ($C_6H_{12}O_6$) and diatomic oxygen gas (O_2). Originally, each carbon dioxide molecule has two oxygen atoms joined to each carbon atom, and each water molecule has two hydrogen atoms joined to each oxygen atom. After the reaction, each glucose molecule has 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms joined together in the form $C_6H_{12}O_6$. This is a chemical change because a new substance is formed with a new chemical composition. (The diatomic oxygen gas is also a new substance formed as a result of the reaction.)

In contrast, when a substance undergoes a purely **physical change** (rather than a chemical change), the chemical composition remains the same. For example, when ice melts into liquid water, the ice and the liquid water each consist of H_2O molecules. In this case, the motion of the molecules and the average separation between the molecules change, but the chemical composition remains the same.

A **chemical reaction** is a process for which two or more substances undergo mutual chemical changes.

For example, in the formation of water, diatomic hydrogen gas molecules (H_2) and diatomic oxygen gas molecules (O_2) react together to form water molecules (H_2O). This reaction involves three substances: H_2, O_2, and H_2O. These three substances undergo mutual chemical changes.

In a chemical reaction, the initial substances are called **reactants** and the final substances are called **products**. In the previous example, the reactants are H_2 and O_2, and the product is H_2O.

A **chemical equation** represents a chemical reaction using symbols for the different types of atoms, with the reactants added together on the left-hand side and the products added together on the right-hand side. A **yield** symbol ($\rightarrow$) separates the reactants from the products.

For example, the chemical equation below represents the formation of water. This equation states that two parts diatomic hydrogen gas and one part diatomic oxygen gas form two parts water.

$$2H_2 + O_2 \rightarrow 2H_2O$$

The plus signs ($+$) and yield symbol ($\rightarrow$) separate the **terms** of a chemical equation.

For example, in the chemical equation $2H_2 + O_2 \rightarrow 2H_2O$, there are three terms: $2H_2$, O_2, and $2H_2O$.

A small number that appears down and to the right of an atom is called a **subscript**.

Examples of subscripts include the 4 in CH_4 and the 2 in Na_2O.

A **coefficient** is a number that appears to the left of a molecule in a chemical equation to indicate how much of the substance is involved. The coefficient multiplies every atom in the substance, as we'll discuss in Chapter 2.

Examples of coefficients include the 5, 3, and 4 in the following chemical equation: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$. The term $5O_2$ has 10 oxygen atoms since there are 5 O_2 molecules and each O_2 molecule has 2 oxygen atoms. Similarly, $3CO_2$ has 3 carbon atoms and 6 oxygen atoms, and $4H_2O$ has 8 hydrogen atoms and 4 oxygen atoms.

When the number of each type of atom is the same on both sides of a chemical equation, it is said to be **balanced**.

An example of a balanced chemical equation is:

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

This equation is balanced because there are 2 Fe atoms on each side, 6 oxygen atoms on each side, and 3 carbon atoms on each side.

Chemical equations are balanced because the **law of conservation of mass** states that atoms are neither created nor destroyed in a chemical reaction. This law applies to ordinary chemical reactions. (It does not apply to nuclear reactions, which is a different subject.)

2 Counting Atoms

In the chemical formula for a compound, subscripts indicate the number of each type of atom present in one molecule. If the symbol for an element doesn't have a subscript, there is just one atom of that type in the molecule. Subscripts are used when there are two or more atoms of a given type.

For example, H_3PO_4 has 3 H atoms, 1 P atom, and 4 O atoms.

Example 1: How many atoms of each type are present in one molecule of NH_3?

- 1 N atom
- 3 H atoms

Example 2: How many atoms of each type are present in one molecule of C_3H_8?

- 3 C atoms
- 8 H atoms

Example 3: How many atoms of each type are present in one molecule of H_2SO_4?

- 2 H atoms
- 1 S atom
- 4 O atoms

Name: ________________________________

Directions: Indicate the number of atoms of each type present in one molecule of each substance.

(1) Mg_3N_2

(2) K_2S

(3) N_2O_5

(4) $BeCl_2$

(5) LiF

(6) H_2

(7) NH_4Cl

(8) Na_2SO_3

(9) H_2SiF_6

(10) H_3PO_4

(11) $C_6H_{12}O_6$

(12) C_2H_5OH