3.3 Chemical equations describe the process of chemical change.

3.3.1 Writing and Balancing Chemical Equations

Chemical change involves the conversion of starting materials (**reactants**) into different substances (**products**) with different properties. This is called a **chemical reaction**. Chemical reactions are represented symbolically using a **chemical equation**, which may be written in words or symbols. For example:

word equation: hydrogen + oxygen → water

formula equation: $2\,H_{2(g)} + O_{2(g)} \rightarrow 2\,H_2O_{(l)}$

Besides showing the chemical formulas (H_2, O_2, and H_2O), the formula equation may show the following:

- **balancing coefficients**: integers placed in front of the formulas. Coefficients show the ratios in which the chemicals are consumed and produced. In the example above, two molecules of hydrogen react with one molecule of oxygen to form two molecules of water.

- **states**: letters indicating the compound's state: *(g)* for gas; *(l)* for liquid; *(s)* for solid; *(aq)* for aqueous (dissolved in water)

Sometimes energy is also included in the chemical equation. One of the most important reactions on Earth is photosynthesis in green plants. Light from the Sun usually provides the energy to drive this reaction. Most of the food you eat depends ultimately upon the production of the sugar called glucose ($C_6H_{12}O_6$), which is made in this reaction:

word equation: energy + carbon dioxide + water → glucose + oxygen

formula equation: energy + $6\,CO_2 + 6\,H_2O \rightarrow C_6H_{12}O_6 + 6\,O_2$

Notice that states were not included in this formula equation. Formula equations can be written with or without states.

Study Prep

Refer to the photosynthesis equation above to answer the following:

1. List the names of the reactants.

2. List the formulas of the products.

3. How many molecules of carbon dioxide are required to produce one molecule of glucose?

4. Does the photosynthesis reaction consume energy or release it?

5. What is the symbol that means "combines with" in a chemical reaction?

6. What is the symbol that means "produces" in a chemical reaction?

7. How many molecules of glucose and oxygen are produced when 24 molecules of carbon dioxide react with 24 molecules of water?

Balancing Equations

The first step in writing a balanced chemical equation is the **skeleton equation**. A skeleton equation shows only the formulas of the reactants and the products. It does not usually show the correct proportion in which the reactants need to be combined. The skeleton equation for the reaction of sodium metal with oxygen gas to form sodium oxide is:

skeleton equation: $Na + O_2 \rightarrow Na_2O$

You can then add balancing coefficients to write a **balanced equation**. These integers show the proportions in which the reactants must be combined and in which the products are produced. The balanced equation for the above reaction is:

balanced equation: $4\,Na + O_2 \rightarrow 2\,Na_2O$

The coefficient in front of Na is 4. The O_2 does not have a coefficient shown in front of it because only one molecule of O_2 is required. The value of 1 is implied.

This equation can be read: "Combine four atoms of Na with one molecule of O_2 to produce two formula units of Na_2O." Like any recipe used in cooking, it is possible to "double" the recipe, so that it is also true that eight atoms of Na will combine with two molecules of O_2 to produce four formula units of Na_2O. However, in a balanced chemical equation, the smallest whole number ratio is always used. In this case, that ratio is 4:1:2.