8.1 Introduction to Chemical Reactions

Lesson Objectives

- Describe how chemical reactions occur.
- List signs that a chemical reaction has occurred.

Lesson Vocabulary

- chemical reaction
- equilibrium
- product
- reactant

What Is a Chemical Reaction?

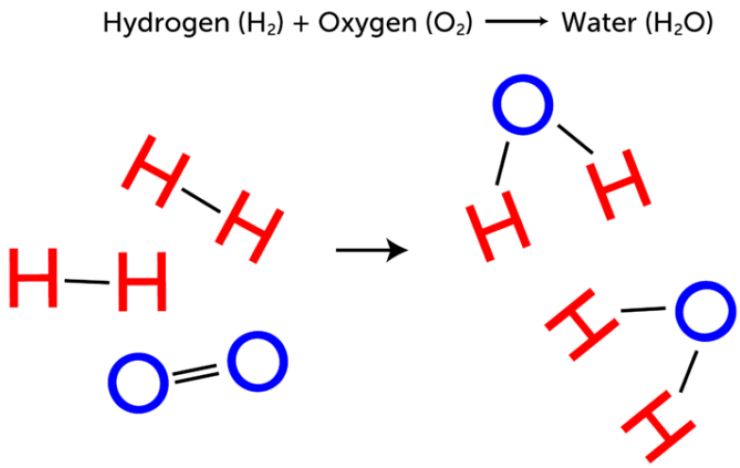
A **chemical reaction** is a process in which some substances change into different substances. Substances that start a chemical reaction are called **reactants**. Substances that are produced in the reaction are called **products**. Reactants and products can be elements or compounds. A chemical reaction can be represented by this general equation:

$$\text{Reactants} \rightarrow \text{Products}$$

The arrow ($\rightarrow$) shows the direction in which the reaction occurs. The reaction may occur quickly or slowly. For example, foam shoots out of a fire extinguisher as soon as the lever is pressed. But it might take years for metal to rust.

Breaking and Reforming Chemical Bonds

In chemical reactions, bonds break in the reactants and new bonds form in the products. The reactants and products contain the same atoms, but they are rearranged during the reaction. As a result, the atoms are in different combinations in the products than they were in the reactants.



Evidence of Chemical Reactions

How can you tell whether a change in matter involves a chemical reaction? Often, there is evidence. Four common signs that a chemical reaction has occurred are:

- Change in color: the products are a different color than the reactants.
- Change in temperature: heat is released or absorbed during the reaction.
- Production of a gas: gas bubbles are released during the reaction.
- Production of a solid: a solid settles out of a liquid solution. The solid is called a precipitate.

8.2 Chemical Equations

Word Equations

You can describe a chemical reaction by writing a word equation. When silver metal is exposed to sulfur it reacts to form silver sulfide. Silver sulfide is commonly known as tarnish and turns the surface of silver objects dark and streaky black (**Figure** 8.4) The sulfur that contributes to tarnish can come from traces of sulfur in the air or from food such as eggs. The word equation for the process is:

Silver + sulfur → Silver sulfide

The silver and the sulfur are the reactants in the equation, while the silver sulfide is the product.

Another common chemical reaction is the burning of methane gas. Methane is the major component of natural gas and is commonly burned on a gas stove or in a Bunsen burner (**Figure** 8.5). Burning is a chemical reaction in which some type of fuel is reacted with oxygen gas. The products of the reaction in the burning of methane as well as other fuels are carbon dioxide and water. The word equation for this reaction is:

Methane + oxygen → carbon dioxide + water

Chemical Equations

Word equations are time-consuming to write and will not prove to be convenient for many of the things that chemists need to do with equations. A **chemical equation** *is a representation of a chemical reaction that displays the reactants and products with chemical formulas*'. The chemical equation for the reaction of methane with oxygen is shown:

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

The equation above, called a **skeleton equation**, *is an equation that shows only the formulas of the reactants and products with nothing to indicate the relative amounts*. The first step in writing an accurate chemical equation is to write the skeleton equation, making sure that the formulas of all substances involved are written correctly. All reactants are written to the left of the yield arrow, separated from one another by a plus sign. Likewise, products are written to the right of the yield arrow, also separated with a plus sign.

It is often important to know the physical states of the reactants and products taking part in a reaction. To do this, put the appropriate symbol in parentheses after each formula: (*s*) for solid, (*l*) for liquid, (*g*) for gas, and (*aq*) for an aqueous (water-based) solution. The previous reaction becomes:

$$CH_{4(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_{2(l)}O$$

Balancing Chemical Equations

$$\text{Ham} + \text{cheese} + \text{tomato} + \text{pickles} + \text{bread} \rightarrow \text{ham sandwich}$$

The reactants are the "parts" or ingredients of the ham sandwich while the sandwich itself is the product. There is something missing from your equation, however. There is no indication how many of each "reactant" is required to make the "product." For one thing, you would certainly need 2 slices of bread to make a conventional sandwich.

Let's say that the perfect ham sandwich (HS) is composed of 2 slices of ham (H), a slice of cheese (C), a slice of tomato (T), 5 pickles (P), and 2 slices of bread (B). Accounting for the numbers of each reactant, as well as substituting symbols for words, your equation would become:

$$2\text{H} + \text{C} + \text{T} + 5\text{P} + 2\text{B} \rightarrow \text{HS}$$

This now shows the correct quantities of the reactants. As one final improvement, we will change the "formula" of the product. Since the final sandwich contains all the reactants that went into it, its formula should reflect that.

$$2\text{H} + \text{C} + \text{T} + 5\text{P} + 2\text{B} \rightarrow \text{H}_2\text{CTP}_5\text{B}_2$$

The subscript after each symbol in the product stands for the number of that particular reactant found on the reactant side of the equation: 2 for H, 1 for C, etc.

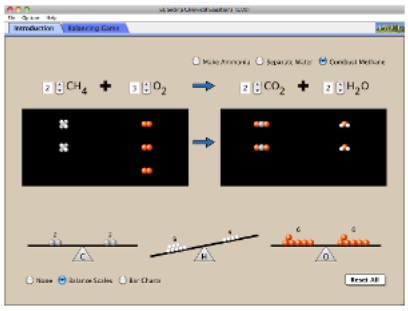
Since the equation now shows equal numbers of each sandwich part on both sides of the equation, we say that the equation is balanced. Chemical equations must also be balanced in a similar way. A **balanced equation** *is a chemical equation in which mass is conserved and there are equal numbers of atoms of each element on both sides of the equation.* We can write a chemical equation for the reaction of carbon with hydrogen gas to form methane (CH_4).

$$\underset{1\text{ C atom}}{?\ \text{C}_{(s)}} + ?\ \underset{2\text{ H atoms}}{\text{H}_{2(g)}} \rightarrow ?\ \underset{1\text{ C atom, }4\text{ H atoms}}{\text{CH}_{4(g)}}$$

Balancing Equations Guidelines

1. Determine the correct chemical formulas for each reactant and product.
2. Write the skeleton equation by placing the reactant(s) on the left side of the yield sign (→) and the product(s) on the right side. If there is more than one reactant or product, separate with plus signs.
3. Count the number of atoms of each element that appears as a reactant and as a product. If a polyatomic ion is unchanged on both sides of the equation, count it as a unit.
4. Balance each element on at a time by placing coefficients in front of the formulas. No coefficient is written for a 1. It is best to begin by balancing elements that only appear in one formula on each side of the equation. NEVER change the subscripts in a chemical formula – you can only balance equations by using coefficients.
5. Check each atom or polyatomic ion to be sure that they are equal on both sides of the equation.
6. Make sure that all coefficients are in the lowest possible ratio. If necessary, reduce to the lowest ratio.

Balancing Chemical Equations



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