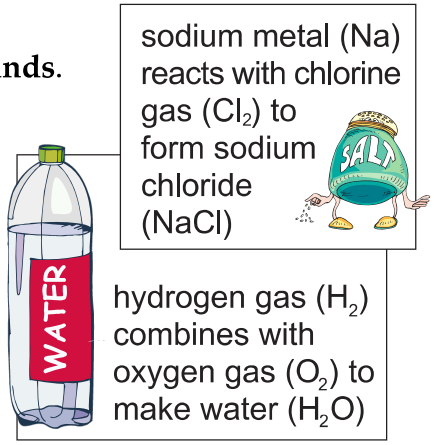
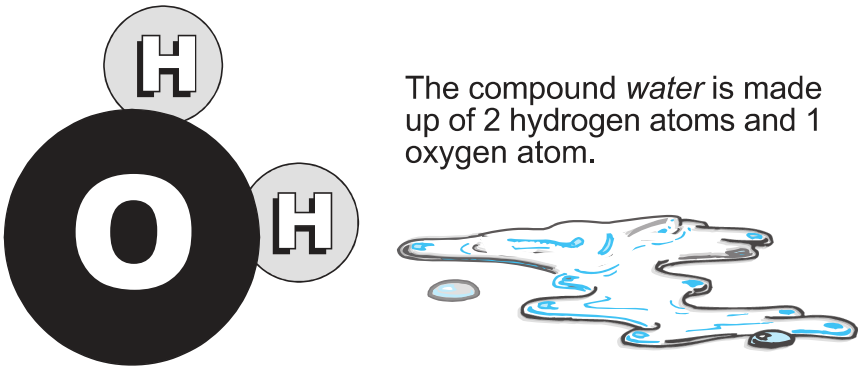
Introduction

You have learned that **atoms** of different **elements** can combine to form new **compounds**. When this takes place, a chemical reaction occurs. For example, sodium metal (Na) reacts with chlorine gas (Cl_2) to form sodium chloride (NaCl). Hydrogen gas (H_2) combines with oxygen gas (O_2) to make water (H_2O). Scientists have a special way to write about these reactions. In this unit, you will learn to **balance** simple **chemical formula** and **chemical equations**.



Chemical Formulas

A *chemical formula* is used to represent a *compound*. Scientists use formulas as a shorthand way to write compounds. **Symbols** stand for the elements in compounds. NaCl is the formula for table salt. The formula shows that the compound, table salt, is made from the elements sodium and chlorine. The formula for water is H_2O. This states that the compound water is made up of hydrogen and oxygen. Notice that the formula for water has a small two after the H. That small number is called a **subscript**. It tells how many *atoms* of the element are in the **molecule**. H_2O means that it takes two atoms of hydrogen and one atom of oxygen to make a *molecule* of water. If there is no *subscript* after the *symbol*, it means there is only one atom.



The formula NaCl shows that salt is made from one atom of sodium and one atom of chlorine. Let's look at some simple chemical formulas.

Name	Formula	Number of Atoms
hydrogen peroxide	H_2O_2	2 atoms H, 2 atoms O
methane (natural gas)	CH_4	1 atom C, 4 atoms H
carbon dioxide	CO_2	1 atom C, 2 atoms O

When you understand subscripts, it is easy to tell how many atoms are in one molecule of a compound. $C_{12}H_{22}O_{11}$ is the formula for sucrose (common granulated sugar is sucrose). It contains 12 atoms of C, 22 atoms of H, and 11 atoms of O.

Chemical Equations

Elements always combine with each other in a certain way. You know that NaCl is the formula for salt. We could write the sentence, *"Sodium plus chlorine makes sodium chloride."* Scientists use a shorter way to describe this reaction. This shorter way is called a *chemical equation*. Look at the following equation for the formation of sodium chloride:

$$2Na + Cl_2 \longrightarrow 2NaCl$$

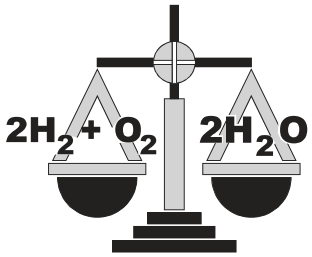
The arrow stands for the word makes *or* **yields**.

The arrow stands for the word *makes* or **yields**. When a chemist reads this equation he might say, *"Sodium plus chlorine* yields *sodium chloride."* Using equations saves time. Think how long it would take to write the following equation in words:

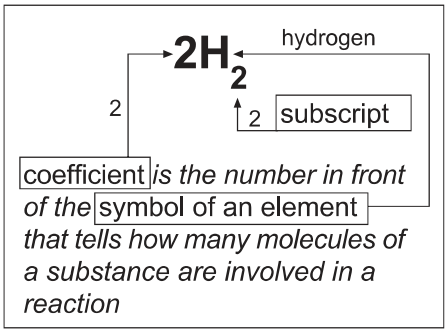
$$NaOH + HCl \longrightarrow NaCl + H_2O$$

It would be simple if all chemical reactions took place with equal parts of all **substances**. However, this is not true. You already know that it takes more atoms of H than O to form water. One equation for water looks like this:

$$2H_2 + O_2 \longrightarrow 2H_2O$$



Think of the two sides of an equation being placed onto a *balance scale*. The left side of the equation must balance the right side. The number of oxygen atoms on the right side of the equation must equal the number of oxygen atoms on the left side. During a chemical reaction, no **matter** is made or lost. All atoms must be taken into account. This means that every atom on the left side of the equation must also be on the right side of the equation.



To determine the total number of atoms in a molecule, the **coefficient** is multiplied by the subscript for each element. For example, we could look at **$2H_2$**. The *coefficient* of two means that two molecules of hydrogen are involved. To determine the number of hydrogen atoms in two molecules of hydrogen, multiply the coefficient (2) by the subscript ($_2$) as follows: Using this method, the equation for water can be broken down like this:

2 molecules x 2 atoms in each molecule = 4 atoms.

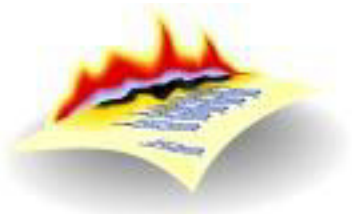
$2H_2$	+	O_2	→	$2H_2O$
(2 molecules of hydrogen)	+	(1 molecule of oxygen*)	→	(2 molecules of water)
4 atoms	+	2 atoms	→	4 atoms of H + 2 atoms of O
		6 atoms	→	6 atoms

* If there is no number before the symbol of an element, the coefficient is *understood* to be *one*.

Notice that the numbers of each type of atom on each side of the equation are equal. We say that the equation is balanced.

The Law of Conservation of Mass

There are some important laws in chemistry. We know that chemical equations must balance. This is because matter can never be created or destroyed during a chemical reaction. The **mass** of the *substances* is the same before and after a reaction. Matter may change form, but it is never destroyed.



The law of conservation of mass states that matter cannot be created or destroyed—therefore, no matter is destroyed in the burning of the paper.

Iron rusts and paper burns, but no matter is destroyed in either reaction. There is always the same amount of matter at the end of a reaction as there was in the beginning. This is called the **law of conservation of mass**. The law states that matter cannot be created or destroyed during a chemical reaction.

Summary

Chemical formulas are used to name a compound. Chemical equations are the shorthand way of telling what happens during a chemical reaction. All equations must balance. The *law of conservation of mass* states that no matter can be created or destroyed.