Name _____ Class _____ Date _____

CHAPTER 9 | Chemical Reactions

SECTION 2

Chemical Formulas and Equations

California Science Standards

8.3.f, 8.5.b

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do chemical formulas show the elements in a substance?
- How do chemical equations show what happens during a chemical reaction?
- How can you balance a chemical equation?

STUDY TIP

Ask Questions As you read this section, make a list of questions that you have. Talk about your questions with a small group. When you figure out the answers to your questions, write them in your notebook.

What Is a Chemical Formula?

We use letters to form words. We put words together to form sentences. In the same way, scientists use symbols to form chemical formulas that describe different substances. They put chemical formulas together to show how chemical reactions happen.

Remember that substances are formed from different elements. Each element has its own chemical symbol. You can find the symbol for an element in the periodic table. Scientists combine the symbols for different elements into chemical formulas. A **chemical formula** shows which elements are found in a substance. It also shows how many atoms of each element are found in a molecule of the substance. ☑

READING CHECK

1. Identify What are two things that are shown by a chemical formula?

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In order to learn how chemical formulas work, let's look at an example. The chemical formula for water is H_2O. This formula means that a molecule of water is made of two hydrogen (H) atoms and one oxygen (O) atom.

The small 2 in the formula is a subscript. A *subscript* is a number that tells you how many atoms of an element are in a molecule. Subscripts are always written below and to the right of the symbol for an element. If there is no subscript next to an element's chemical symbol, only one atom of the element is found in the substance.

Water

H_2O

Water A molecule of water contains 2 hydrogen (H) atoms and 1 oxygen (O) atom.

Oxygen

O_2

Oxygen A molecule of oxygen is made of 2 oxygen (O) atoms.

Glucose

$C_6H_{12}O_6$

Glucose A molecule of glucose cotains 6 carbon (C) atoms, 12 hydrogen (H) atoms and 6 oxygen (O) atoms.

Math Focus

2. Calculate How many oxygen atoms are in three molecules of water?

_____

FORMULAS FOR COVALENT COMPOUNDS

In many cases, the name of a covalent compound tells you how to write its chemical formula. This is because the names of many covalent compounds use prefixes. These prefixes represent numbers. For example, the prefix *di-* means "two." The prefixes tell you how many atoms of an element are found in a substance. The tables below shows the meanings of different prefixes.

Prefix	Number
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5

Prefix	Number
hexa-	6
hepta-	7
octa-	8
nona-	9
deca-	10

Carbon dioxide

CO_2

The **absence of a prefix** indicates one carbon atom.

The prefix ***di-*** indicates two oxygen atoms.

Dinitrogen monoxide

N_2O

The prefix ***di-*** indicates two nitrogen atoms.

The prefix ***mono-*** indicates one oxygen atom.

FORMULAS FOR IONIC COMPOUNDS

Remember that ions have electrical charges. However, when ions combine to form a substance, the substance does not have an electrical charge. Therefore, the formula for an ionic compound must have subscripts that make the charges of the ions balance. To write a formula for an ionic compound, make sure the charges of all the ions add up to zero. The figure below shows some examples of how to name ionic compounds.

Sodium chloride

$NaCl$

A sodium ion has a **1+ charge.**

A chloride ion has a **1– charge.**

One sodium ion and one chloride ion have an **overall charge of (1+) + (1–) = 0.**

Magnesium chloride

$MgCl_2$

A magnesium ion has a **2+ charge.**

A chloride ion has a **1– charge.**

One magnesium ion and two chloride ions have an **overall charge of (2+) + 2(1–) = 0.**

Critical Thinking

3. Apply Concepts Write a name for the covalent compound whose chemical formula is H_2S.

_____

CALIFORNIA STANDARDS CHECK

8.3.f Students know how to use the periodic table to identify elements in simple compounds.

4. Write a Formula Write the chemical formula for the compound silicon tetrachloride. You can use a periodic table to help you.

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TAKE A LOOK

5. Identify What is the charge on the Fe ion in the ionic compound $FeCl_3$?

_____

How Are Chemical Formulas Used to Write Chemical Equations?

Scientists use chemical equations to describe reactions. A **chemical equation** uses chemical symbols and formulas as a short way to show a chemical reaction. A chemical equation shows that the numbers and kinds of atoms are the same before and after a reaction. ☑

READING CHECK

6. Define What is a chemical equation?

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The starting materials in a chemical reaction are the **reactants**. The substances that form during the reaction are the **products**. In a chemical equation, the reactants and products are written using chemical formulas. Scientists use a plus sign to separate the formulas of two or more reactants or products. An arrow points from the formulas of the reactants to the formulas of the products.

TAKE A LOOK

7. Identify List the reactants and the products of the reaction in the figure. Use chemical formulas in your answer.

reactants: _____

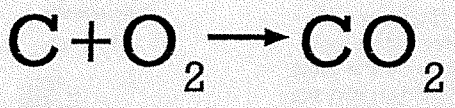
_____

products: _____

Carbon is the main element in charcoal. When charcoal burns, it reacts with oxygen in the air. The reaction produces heat, light, and carbon dioxide.

The formulas of the reactants are written before the arrow.

The formulas of the products are written after the arrow.



A **plus sign** separates the formulas of two or more reactants or the formulas of two or more products.

The **arrow,** also called the *yields sign,* separates the formulas of the reactants from the formulas of the products.

CHECKING SYMBOLS

When you write a chemical formula, it is important that you check to make sure that it is correct. If you use the wrong formula or symbol in an equation, the equation will not describe the correct reaction. Even a small mistake can make a big difference. ☑

READING CHECK

8. Explain Why is it important to check to make sure that your chemical formulas are correct?

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As an example, consider the three formulas Co, CO, and CO_2. These formulas look very similar. However, the substances they represent are very different. Co is the symbol for the element cobalt, a hard, bluish-grey metal. CO is the formula for carbon monoxide, a colorless, poisonous gas. CO_2 is the formula for carbon dioxide, a colorless gas that living things give off when they breathe.

CONSERVING MASS

The **law of conservation of mass** states that mass can not be created or destroyed during a chemical reaction. The total mass of the reactants in a chemical reaction is the same as the total mass of the products. You can use this law to help you figure out how to write a chemical equation.

During a chemical reaction, atoms are not lost or gained. Every atom in the reactants becomes part of the products. Therefore, in a chemical equation, the numbers and kinds of atoms in the reactants and products must be equal. In other words, the chemical equation must be *balanced*.

CALIFORNIA STANDARDS CHECK

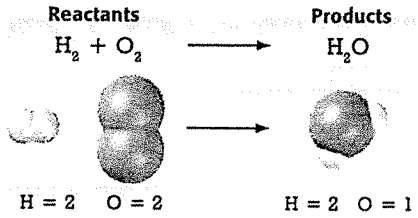
8.5.b Students know the idea of atoms explains the conservation of matter: In chemical reactions the number of atoms stays the same no matter how they are arranged, so their total mass stays the same.

9. Explain How can you use the law of conservation of mass to help you balance a chemical equation?

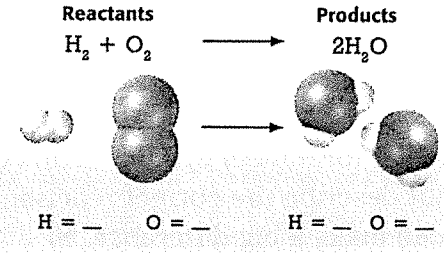
HOW TO BALANCE A CHEMICAL EQUATION

Follow these steps to write a balanced equation for $H_2 + O_2 \longrightarrow H_2O$.

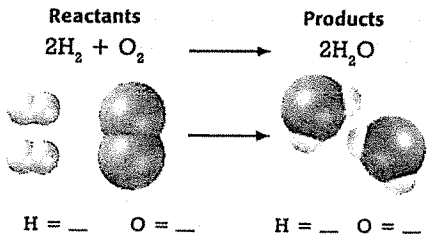
❶ Count the atoms of each element in the reactants and the products. Here, you can see that there are more oxygen atoms in the reactants than in the products. Therefore, the chemical equation is not balanced.



❷ Add coefficients to balance the atoms of oxygen. There are two atoms of oxygen in the reactants. Place the coefficient 2 in front of the products to give two atoms of oxygen in the products. Then, count the atoms again. Now, the hydrogen atoms are not balanced.



❸ Add coefficients to balance the atoms of hydrogen. Add the coefficient 2 to the H_2 reactant to give four atoms of hydrogen in the reactants. Then, count the atoms again to double-check your work.



TAKE A LOOK

10. Identify Fill in the blank lines in the figure to show how many atoms of each element are in the reactants and the products.