Name _____ Date _____

Section **4.3** Summary

Chemical Equations

Textbook pages 202–215

Before You Read

What do you already know about chemical equations? Write your ideas in the lines below.

_____

_____

Create a Table

Create a table that outlines the steps you need to take when writing and balancing chemical equations

Reading Check

List the four states of matter.

_____

_____

_____

_____

Reading Check

What does the law of conservation of mass state?

_____

_____

_____

_____

How are chemical changes and chemical reactions linked?

A chemical change is a change in the arrangements and connections between ions and atoms. Chemical change always involves the conversion of pure substances (elements and compounds) called **reactants** into other pure substances called **products**, which have different properties than the reactants. One or more chemical changes that occur at the same time are called a **chemical reaction**.

How is a chemical reaction represented?

A chemical reaction can be represented using a **chemical equation**. A chemical equation may be written in words (a **word equation**) or in chemical symbols (a **symbolic equation**). In a chemical equation, the reactants are written to the left of an arrow and the products are written to the right. The symbols for **states of matter** may be used to show whether each reactant or product is solid (s), liquid (l), gas (g), or aqueous (aq).

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

Chemical reactions obey the law of **conservation of mass**. Atoms are neither destroyed nor produced in a chemical reaction. The total mass of the products is always equal to the total mass of the reactants.

How are chemical equations written and balanced?

Chemical equations are written and balanced through a series of steps, as shown below.

1. Write a word equation: The simplest form of a chemical equation is a word equation. A word equation provides the names of the reactants and products in a chemical reaction. It provides the starting point for writing and balancing chemical equations.

word equation: methane + oxygen → water + carbon dioxide

2. Write a **skeleton equation**: A **skeleton equation** replaces the names of the reactants and products in a word equation with formulas. However, it does not show the correct proportions in which the reactants will actually combine and the products will be produced.

A skeleton equation is not balanced.

skeleton equation: $CH_4 + O_2 \rightarrow H_2O + CO_2$

3. Write a balanced equation: A **balanced chemical equation** shows the identities of each pure substance involved in the reaction, as well as the number of atoms of each element on both sides of a chemical equation. Chemical equations are balanced using the lowest whole number **coefficients**. These are integers placed in front of the formula or chemical symbol for each product and reactant. The number of atoms after a chemical reaction is the same as it was before a chemical reaction. You can use this information to determine the coefficients that balance the equation.

balanced chemical equation: $CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$

The following strategies can help you translate a word equation into a skeleton equation.

- A chemical symbol is used for nearly all elements when they are not in a compound.
- Three common compounds containing hydrogen that you should memorize are methane (CH_4), ammonia (NH_3), and water (H_2O).

There are seven common diatomic elements, all of which are non-metals. These are hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine, and iodine. When they occur alone (not in a compound), they are written as H_2, O_2, F_2, Br_2, I_2, N_2, and Cl_2. You can use the word "HOFBrINCl" to remember them. If an element occurs alone and is not diatomic, no subscript is used. For example, in a chemical equation, oxygen is written as O_2 when it occurs alone, while lead is written as Pb.

The following strategies can help you balance a skeleton equation.

- Balance compounds first and single elements last.
- If you place a coefficient in front of a formula, be sure to balance all the atoms of that formula before moving on.
- Add coefficients only in front of formulas. Do not change subscripts.
- When oxygen or hydrogen appears in more than one formula on the reactant side or the product side of the chemical equation, balance oxygen and hydrogen last.
- You can often treat polyatomic ions, such as SO_4^{2-}, as a unit.
- If an equation is balanced by using half a molecule (i.e., ½ O_2), you must double all coefficients so that they are all integers.
- When you are finished, perform a final check to be sure that all elements are balanced.

Name _____ Date _____

Comprehension
Section 4.3

Use with textbook pages 206–211.

Balancing equations

Starting with the skeleton equations, balance the following equations by adding coefficients where appropriate.

1. $H_2 + F_2 \rightarrow HF$ _____
2. $Sn + O_2 \rightarrow SnO$ _____
3. $MgCl_2 \rightarrow Mg + Cl_2$ _____
4. $KNO_3 \rightarrow KNO_2 + O_2$ _____
5. $BN + F_2 \rightarrow BF_3 + N_2$ _____
6. $CuI_2 + Fe \rightarrow FeI_2 + Cu$ _____
7. $Li + H_2O \rightarrow LiOH + H_2$ _____
8. $NH_3 + O_2 \rightarrow N_2 + H_2O$ _____
9. $V_2O_5 + Ca \rightarrow CaO + V$ _____
10. $C_9H_6O_4 + O_2 \rightarrow CO_2 + H_2O$ _____
11. $H_2S + PbCl_2 \rightarrow PbS + HCl$ _____
12. $C_3H_7OH + O_2 \rightarrow CO_2 + H_2O$ _____
13. $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$ _____
14. $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ _____
15. $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$ _____
16. $Al + H_2SO_4 \rightarrow H_2 + Al_2(SO_4)_3$ _____
17. $FeCl_3 + Ca(OH)_2 \rightarrow Fe(OH)_3 + CaCl_2$ _____
18. $Pb(NO_3)_2 + K_2CrO_4 \rightarrow PbCrO_4 + KNO_3$ _____
19. $Cd(NO_3)_2 + (NH_4)_2S \rightarrow CdS + NH_4NO_3$ _____
20. $Ca(OH)_2 + NH_4Cl \rightarrow NH_3 + CaCl_2 + H_2O$ _____

Use with textbook pages 202–211.

Word equations

Write the skeleton equation for each of the following reactions. Then balance each of the following chemical equations.

1. hydrogen + oxygen → water

2. iron(III) oxide + hydrogen → water + iron

3. sodium + water → sodium hydroxide + hydrogen

4. calcium carbide + oxygen → calcium + carbon dioxide

5. potassium iodide + chlorine → potassium chloride + iodine

6. chromium + tin(IV) chloride → chromium(III) chloride + tin

7. magnesium + copper(II) sulphate → magnesium sulphate + copper

8. zinc sulphate + strontium chloride → zinc chloride + strontium sulphate

9. ammonium chloride + lead(III) nitrate → ammonium nitrate + lead(III) chloride

10. iron(III) nitrate + magnesium sulphide → iron(III) sulphide + magnesium nitrate

11. aluminum chloride + sodium carbonate → aluminum carbonate + sodium chloride

12. sodium phosphate + calcium hydroxide → sodium hydroxide + calcium phosphate

Name _____ Date _____

Extension
Section 4.3

Use with textbook pages 202–203, 206–211.

Chemical reactions and chemical equations

Rewrite the following sentences as chemical word equations. Then write the skeleton equation and balance the equation.

1. Iron combines with oxygen to form rust, which is also known as iron(II) oxide.

   Word equation: _____
   Balanced equation: _____

2. A solution of hydrogen chloride reacts with sodium carbonate to produce carbon dioxide, sodium chloride, and water.

   Word equation: _____
   Balanced equation: _____

3. When aluminum metal is exposed to oxygen, a metal oxide called aluminum oxide is formed.

   Word equation: _____
   Balanced equation: _____

4. Water reacts with powered sodium oxide to produce a solution of sodium hydroxide.

   Word equation: _____
   Balanced equation: _____

5. Hydrogen gas reacts with nitrogen trifluoride gas to form nitrogen gas and hydrogen fluoride.

   Word equation: _____
   Balanced equation: _____

6. Chromium(III) sulphate reacts with potassium carbonate to form chromium(III) carbonate and potassium sulphate.

   Word equation: _____
   Balanced equation: _____

7. Potassium chlorate when heated becomes oxygen gas and potassium chloride.

   Word equation: _____
   Balanced equation: _____

8. A piece of metallic zinc is placed in a blue solution of copper(II) sulphate. A reddish brown layer of metallic copper forms in a clear solution of zinc sulphate.

   Word equation: _____
   Balanced equation: _____

Use with textbook pages 202–211.

Chemical equations

Match the Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. _____ product	A. a chemical that reacts in a chemical reaction
2. _____ reactant	B. a chemical that forms in a chemical reaction
3. _____ coefficient	C. a chemical change in which new substances are formed
4. _____ word equation	D. a chemical equation that is written using chemical names
5. _____ skeleton equation	E. an integer placed in front of a formula in a chemical equation
6. _____ chemical reaction	F. a chemical equation that is written using chemical formulas
7. _____ chemical equation	G. a set of chemical formulas that identify the reactants and products in a chemical reaction

8. Which of following describes the law of conservation of mass?

I.	The mass is conserved in a chemical reaction.
II.	The total mass of the products is equal to the total mass of the reactants in a chemical reaction.
III.	The total number of each kind of atom at the start of the reaction is equal to the total number of each kind of atom after the reaction.

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

9. How many oxygen atoms are there in the compound lead(IV) bisulphate, $Pb(HSO_4)_4$?

A. 2 C. 8

B. 4 D. 16

10. Which of the following are diatomic elements?

I.	iodine
II.	nitrogen
III.	hydrogen

A. I and II only C. II and III only

B. I and III only D. I, II, and III

Use the following unbalanced equation to answer question 11.

$$PCl_5 + H_2O \rightarrow HCl + H_3PO_4$$

11. Which of the following sets of coefficients will balance the equation?

A. 1, 4, 5, 1 C. 1, 3, 5, 2

B. 1, 5, 4, 1 D. 1, 4, 2, 1

12. A solution of sodium sulphide is mixed with a solution of copper(II) nitrate. A precipitate of copper sulphide is formed in a solution of sodium nitrate. What are the reactants in this chemical reaction?

A. Na_2S and CuS

B. CuS and $NaNO_3$

C. Na_2S and $Cu(NO_3)_2$

D. Na_2SO_4 and Cu_2NO_3

13. A piece of aluminum metal is placed in a solution of sulphuric acid, H_2SO_4. A compound, aluminum sulphate, forms and bubbles are seen going to the surface. What type of gas formed during this reaction?

A. oxygen C. carbon dioxide

B. hydrogen D. carbon monoxide