Name _____ Class _____ Date _____

11 Chemical Reactions

Big idea REACTIONS

11.1 Describing Chemical Reactions

For students using the Foundation edition, assign problems 1–17.

Essential Understanding Chemical reactions are represented by balanced chemical equations.

Lesson Summary

Introduction to Chemical Equations A chemical equation uses symbols, and sometimes words, to show the reactants and products of a chemical reaction.

- A skeleton equation uses chemical formulas to represent reactants and products, but it does not indicate the relative amounts of each.
- Anything that enters into a reaction, such as heat or a catalyst, but is not a reactant or product is shown above or below the yields arrow in the equation.

Balancing Chemical Equations Chemical equations are balanced to show that mass is conserved during chemical reactions.

- A balanced equation shows the relative amounts of reactants and products, and it contains equal numbers of each type of atom on both sides of the equation.
- Chemical equations are balanced by using coefficients in front of the chemical formulas for the reactants and the products in a skeleton equation.

BUILD Math Skills

Balancing Equations All chemical equations must be balanced because of the law of conservation of mass, which states that matter cannot be created or destroyed. So, the number of atoms that you start with at the beginning of the reaction must equal the number of atoms that you end up with.

For example, the reaction $2Mg + O_2 \rightarrow 2MgO$ follows the law of conservation of mass because you start with 2 magnesium atoms and 2 oxygen atoms and you end up with 2 magnesium atoms and 2 oxygen atoms. You can think of the $\rightarrow$ as an $=$ sign.

Turn the page to learn more about balancing equations.

Name _____ Class _____ Date _____

When balancing an equation, there are a few rules to remember:

- The subscripts of the molecules can never be altered. Only coefficients can be added.
- The coefficient placed in front of a molecule applies to all elements that make up that molecule.
- The number of atoms can be found by multiplying the coefficient by the subscript of the element. If no subscript appears, a subscript of 1 should be assumed.
- Molecules made up of many elements should have coefficients added first, with single elements remaining until last.
- If a molecule is placed in a parentheses with a subscript outside the parentheses, the subscript applies to all elements within the parentheses. If an element within the parentheses has a subscript, then you will multiply the subscripts to get the number of atoms.

Sample Problem Balance this equation: $N_2 + H_2 \rightarrow NH_3$.

First, add a coefficient to the molecule that contains the most elements. Because there are 2 nitrogen atoms in N_2, add a coefficient 2 in front of NH_3 so that the number of nitrogen atoms on each side are equal.

$N_2 + H_2 \rightarrow 2NH_3$

Next, look at how many hydrogen atoms are present. Hydrogen has a coefficient of 2 and a subscript of 3. So, $2 \times 3 = 6$ hydrogen atoms.

$N_2 + H_2 \rightarrow 2NH_3$

Since 6 hydrogen atoms are present on the right side of the equation, the left side must be balanced by adding a coefficient of 3.

$N_2 + 3H_2 \rightarrow 2NH_3$

Finally, check that the number of atoms for each element are equal on both sides of the equation.

(reactants) $\rightarrow$ (products)

$N_2 + 3H_2 \rightarrow 2NH_3$

2 N atoms + 6 H atoms = 2 N atoms + 6 H atoms

Both sides are equal!

$N_2 + 3H_2 \rightarrow 2NH_3$

(balanced)

Hint: Remember that subscripts included in equations can never be altered. Only coefficients can be added to balance the equation.

Now it's your turn to practice balancing chemical equations. Remember that you will multiply the coefficients by the subscripts to get the total number of atoms.

1. Balance the equation for the reaction of benzene and hydrogen to form cyclohexane.

_____ C_6H_6 + ___3___ $H_2 \rightarrow C_6H_{12}$

Name _____ Class _____ Date _____

2. Balance the equation for ethane, C_2H_6, burning in oxygen to form carbon dioxide and steam.

   ___2___ C_2H_6 + ___7___ O_2 → ___4___ CO_2 + ___6___ H_2O

3. Balance this chemical equation.

   _____ Fe_2O_3 + ___3___ H_2SO_4 → _____ $Fe_2(SO_4)_3$ + ___3___ H_2O

4. Balance the equation for aluminum burning in oxygen to form aluminum oxide.

   ___4___ Al + ___3___ O_2 → ___2___ Al_2O_3

5. Balance the equation for ammonium carbonate so that it breaks down into gaseous ammonia, carbon dioxide, and steam.

   _____ $(NH_4)_2CO_3$ → ___2___ NH_3 + _____ CO_2 + _____ H_2O

After reading Lesson 11.1, answer the following questions.

Introduction to Chemical Equations

6. A chemical reaction occurs when one or more ***reactants*** change into one or more new substances called ***products***.

7. The arrow in a reaction means ***yields, gives, or reacts to produce***.

8. Is the following sentence true or false? When there are two or more reactants or products, they are separated by an arrow. ***false***

9. Write a word equation that describes the following reactions.

   a. Acetylene reacts with oxygen to produce carbon dioxide and water.

   acetylene + oxygen → carbon dioxide + water

   b. When heated, mercury(II) oxide chemically changes to form mercury and oxygen.

   mercury(II) oxide → mercury + oxygen

10. What is a chemical equation?

    A chemical equation is a representation of a chemical reaction; the formulas of the reactants (on the left) are connected by an arrow with formulas of the products (on the right).

11. A chemical reaction that shows only the formulas but not the relative amounts of the reactants and products is a(n) ***skeleton equation***.

12. Identify the reactant(s) and product(s) in the chemical equation Li + Br_2 → LiBr.

    a. reactant(s) ***Li and Br_2*** **b.** product(s) ***LiBr***

13. Circle the letter of each statement that is true about a catalyst.

    a. A catalyst is the new material produced as a result of a chemical reaction.

    b. A catalyst is not used up in a chemical reaction.

    c. A catalyst adds heat to a chemical reaction.

    d. A catalyst speeds up a chemical reaction.

Name _____ Class _____ Date _____

14. Use the symbols in Table 11.1 to write a skeleton equation for the following chemical reaction. Hydrochloric acid reacts with zinc to produce aqueous zinc(II) chloride and hydrogen gas.

HCl(aq) + Zn(s) → $ZnCl_2$(aq) + H_2(g)

Balancing Chemical Equations

15. What is the law of conservation of mass?

In any physical or chemical change, mass is neither created nor destroyed.

16. Complete the flowchart for balancing equations.

Determine the correct formulas and physical states for the ***reactants*** and ***products***.

↓

Write a ***skeleton equation*** with the formulas for the reactants on the left and the formulas for the products on the right of a yields sign (→).

↓

Count the number of ***atoms*** of each element in the reactants and in the products.

↓

Balance the number of atoms of the elements on the two sides of the equation by placing ***coefficients*** in front of formulas. Never try to balance an equation by changing the ***subscripts*** in formulas.

↓

Check each atom or polyatomic ion to be sure the equation is ***balanced***, and make sure that all coefficients are in the ***lowest*** possible ratio.

17. Balance the following chemical equations.

a. ___2___ $Na(s)$ + ___2___ $H_2O(l)$ → ___2___ $NaOH(aq)$ + $H_2(g)$

b. ___2___ $AgNO_3(aq)$ + $Zn(s)$ → $Zn(NO_3)_2(aq)$ + ___2___ $Ag(s)$

Name _____ Class _____ Date _____

11.2 Types of Chemical Reactions

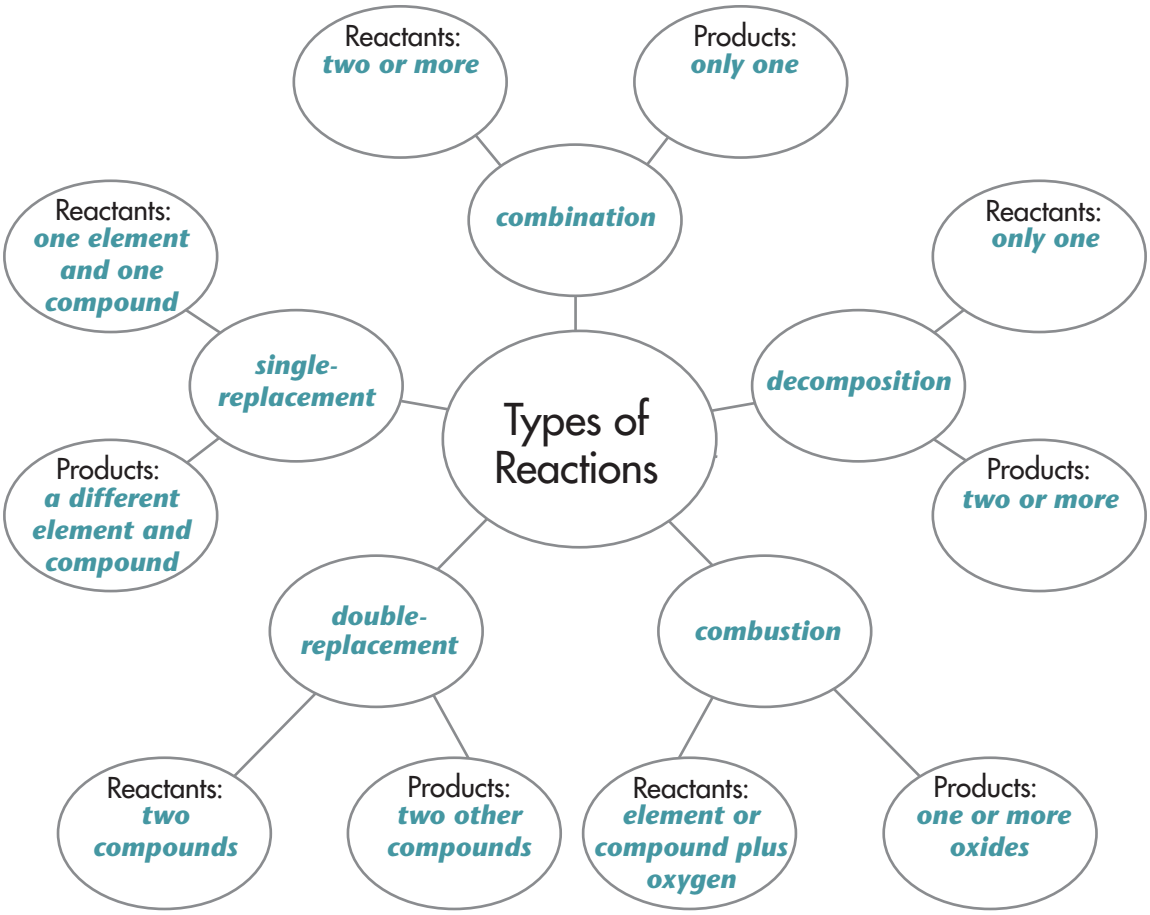
For students using the Foundation edition, assign problems 1–15.

Essential Understanding There are five types of chemical reactions: combination, combustion, decomposition, single-replacement, and double-replacement reactions.

Reading Strategy

Cluster Diagram Cluster diagrams help you show how concepts are related. To create a cluster diagram, write the main idea or topic in a center circle. Draw lines branching off the main idea, connected to circles that contain concepts related to the main concept. Continue adding facts and details to the branches.

As you read Lesson 11.2, use the cluster diagram below. Fill in each type of reaction, then add details to each.



EXTENSION **Write a balanced chemical equation for an example of each type of reaction.**

Sample examples: Combination: $2Na + Cl_2 \rightarrow 2NaCl$; Decomposition: $H_2CO_3 \rightarrow H_2O + CO_2$; Single-replacement: $2K + MgBr_2 \rightarrow 2KBr + Mg$; Double-replacement: $Pb(NO_3)_2 + 2KI \rightarrow 2KNO_3 + PbI_2$; Combustion: $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

Name _____ Class _____ Date _____

Lesson Summary

Classifying Reactions There are five general types of chemical reactions.

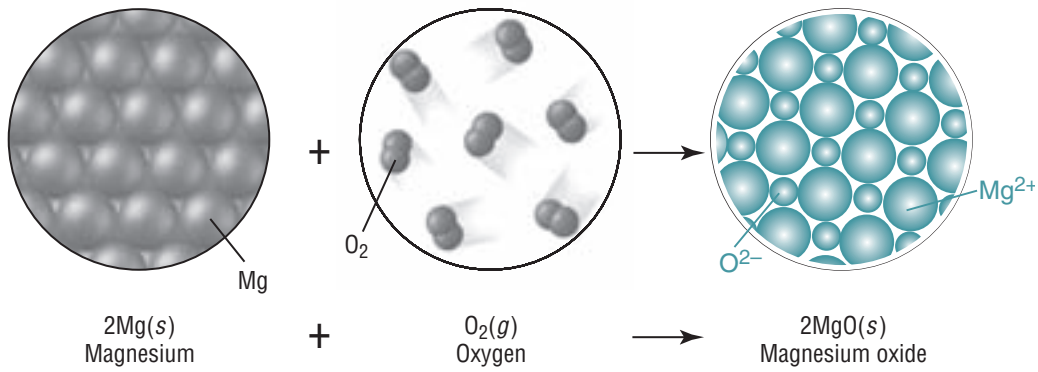
- A combination reaction occurs when a product is formed from two or more reactants, while a decomposition reaction involves breaking down a reactant into two or more simpler substances.
- In single and double-replacement reactions, elements or ions trade places in compounds.
- A compound or an element rapidly combines with oxygen in a combustion reaction.

After reading Lesson 11.2, answer the following questions.

Classifying Reactions

1. There are *five* general types of chemical reactions.
2. Complete the diagram of a combination reaction. Which characteristic of this type of reaction is shown in the diagram?

Two reactants combine to form a single compound.



3. Is the following sentence true or false? The product of a combination reaction is always a molecular compound. *false*
4. Circle the letter of each set of reactants that can produce more than one product.

(a.) two nonmetals

b. a Group A metal and a nonmetal

(c.) a transition metal and a nonmetal

d. two metals

Name _____ Class _____ Date _____

5. Look at Figure 11.5. Which characteristics of a decomposition reaction are shown in the diagram?

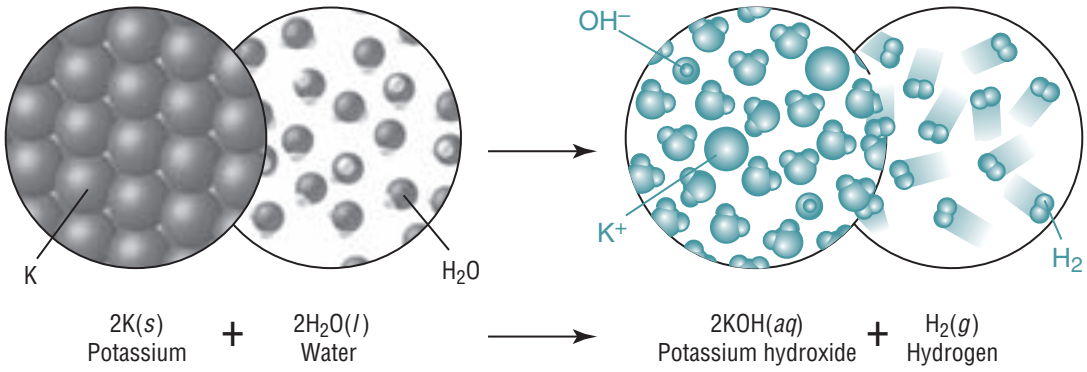
The reaction has a single reactant, which is a binary compound. The products are two elements.

6. Rapid decomposition reactions can cause ***explosions*** as a result of the formation of gaseous products and heat.

7. Most decomposition reactions require the addition of ***energy*** in the form of heat, light, or electricity.

8. Complete the diagram of a single-replacement reaction. Which characteristics of this type of reaction are shown in the diagram?

One element in a compound is replaced by another element.



9. Using Table 11.2, state whether the following combinations will produce a reaction or no reaction.

a. $Ag(s) + HCl(aq)$ ***no reaction***

b. $Cu(s) + AgNO_3(aq)$ ***reaction***

10. Look at Figure 11.7. Which characteristics of a double-replacement reaction are shown in the diagram?

The reaction involves the exchange of positive ions between two ionic compounds in an aqueous solution. One product precipitates from solution.

11. When solutions of ionic compounds are mixed, what three circumstances might indicate that a double-replacement reaction has occurred?

a. ***formation of a precipitate***

b. ***formation of a gas***

c. ***formation of a small molecule, such as water***

12. Look at the diagram of a combustion reaction in Figure 11.8. Which characteristics of this type of reaction are shown in the diagram?

One reactant is a compound, and the other is oxygen. Carbon dioxide and water are formed.

Name _____ Class _____ Date _____

13. Is the following sentence true or false? Hydrocarbons, compounds of hydrogen and carbon, are often the reactants in combustion reactions. ***true***

14. Circle the letter of each compound that can be produced by combustion reactions.

a. oxygen

b. carbon dioxide

c. water

d. glucose

15. Classify the reaction in each of the following equations.

a. $BaCl_2(aq) + K_2CrO_4(aq) \rightarrow BaCrO_4(s) + 2KCl(aq)$ ***double-replacement***

b. $Si(s) + 2Cl_2(g) \rightarrow SiCl_4(l)$ ***combination***

c. $2C_6H_6(l) + 15O_2(g) \rightarrow 6H_2O(l) + 12CO_2(g)$ ***combustion***

16. Use the summary of reaction types on pages 366 and 367. The equation for the combustion of pentane is $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$. What numbers in this equation are represented by *x* and y in the general equation? ***5, 12***

11.3 Reactions in Aqueous Solution

For students using the Foundation edition, assign problems 1–3, 5, 8.

Essential Understanding Reactions that occur in aqueous solutions are double-replacement reactions. The products are precipitates, water, or gases.

Lesson Summary

Net Ionic Equations Net ionic equations show what species present in solution actually are part of the chemical reaction.

- A complete ionic equation includes all ions present in solution, including spectator ions.
- A net ionic equation includes only the particles that participate in the reaction.
- The charges and atoms must be balanced in a net ionic equation.

Predicting the Formation of a Precipitate Solubility laws are used to predict the formation of a precipitate.

- A precipitate forms when one of the possible products of a double-replacement reaction is insoluble in water.
- In a net ionic equation for a double-replacement reaction with a precipitate, the ions that form the precipitate are the reactants and the precipitate is the product.

After reading Lesson 11.3, answer the following questions.

Net Ionic Equations

1. Many important chemical reactions take place in ***aqueous solution***.

Name _____ Class _____ Date _____

2. An equation that shows dissolved ionic compounds as their free ions is called a(n) ***complete ionic equation***.

3. Is the following sentence true or false? A spectator ion is not directly involved in a reaction. ***true***

4. What is a net ionic equation?

A net ionic equation is a chemical equation that shows only those particles that actually take part in the reaction.

5. Circle the letter of each sentence that is true about ionic equations.

   a. A complete ionic equation shows only the ions involved in the reaction.

   b. Spectator ions are left out of a net ionic equation.

   c. Atoms do not need to be balanced in an ionic equation.

   d. Ionic charges must be balanced in a net ionic equation.

6. Write the balanced net ionic equation for this reaction: $Pb(NO_3)_2(aq) + KI(aq) \rightarrow PbI_2(s) + KNO_3(aq)$. Show your work.

Write the complete ionic equation:

$Pb^{2+}(aq) + NO_3^-(aq) \rightarrow K^+(aq) + I^-(aq) \rightarrow PbI_2(s) + K^+(aq) + NO_3^-(aq)$

Eliminate the spectator ions: $Pb^{2+}(aq) + I^-(aq) \rightarrow PbI_2(s)$

Balance the atoms and charges: $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$

Predicting the Formation of a Precipitate

7. What determines whether a precipitate forms when two solutions of ionic compounds are mixed?

The solubilities of the new ionic compounds determine whether a precipitate will form.

8. Use Table 11.3 to predict whether the following compounds are soluble or insoluble.

   a. $Fe(OH)_3$ ***insoluble***

   b. NaOH ***soluble***

   c. $Ca(ClO_3)_2$ ***soluble***

   d. $HgSO_4$ ***insoluble***

Name _____ Class _____ Date _____

Guided Practice Problems

Answer the following questions about Practice Problem 2.

Sulfur burns in oxygen to form sulfur dioxide. Write a skeleton equation for this chemical reaction.

Analyze

Step 1. Write the formula for each reactant and each product. Include the common STP state of each substance.

Reactants

S(s)

$O_2(g)$

Products

$SO_2(g)$

Solve

Step 2. Write the skeleton equation using + between reactants on the left side and → to separate the reactants from the product.

$S(s) + O_2(g) \rightarrow SO_2(g)$

Answer the following questions about Practice Problem 3.

Balance the equation:

$$CO + Fe_2O_3 \rightarrow Fe + CO_2$$

Analyze

Step 1. Count the number of atoms of each element on both sides of the skeleton equation.

Left side:

1 C

2 Fe

3 O

Right side:

1 C

1 Fe

2 O

Name _____ Class _____ Date _____

Solve

Step 2. Identify any necessary coefficient.

The product containing Fe needs a coefficient of 2. Two different reactants contain O. Looking at the equation, each CO takes an O from Fe_2O_3. There are 3 Os in Fe_2O_3, so CO needs a coefficient of 3. To balance C atoms, CO_2 needs a coefficient of 3.

Rewrite the equation with these coefficients and count again:

$$3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$$

Left side:	**Right side:**
3 C	*3 C*
2 Fe	*2 Fe*
6 O	*6 O*

Because the number of atoms of each element is the same on both sides, the equation is balanced.

Answer the following questions about Practice Problem 13.

Complete and balance this decomposition reaction:

$$HI \rightarrow$$

Analyze

Step 1. Identify the relevant concepts.

Remember that both hydrogen and iodine exist as diatomic molecules.

Solve

Step 2. Write the skeleton equation.

$HI \rightarrow H_2 + I_2$

Step 3. Balance the equation.

$2HI \rightarrow H_2 + I_2$

Name _____ Class _____ Date _____

Answer the following questions about Practice Problem 14.

Write and balance the equation for the formation of magnesium nitride (Mg_3N_2) from its elements.

Analyze

Step 1. Identify the relevant concepts.

Magnesium is a Group 2A metal, which means it will combine with nitrogen, a gas in Group 5A, in a 3:2 ratio. Nitrogen exists as diatomic molecules.

Solve

Step 2. Write the skeleton equation.

$Mg + N_2 \rightarrow Mg_3N_2$

Step 3. Balance the equation.

A coefficient of 3 is needed before the Mg reactant to balance the number of Mg atoms. N is balanced.

$3Mg + N_2 \rightarrow Mg_3N_2$

Answer the following questions about Practice Problem 15a–c.

Complete the equations for these single-replacement reactions in aqueous solution. Balance each equation. Write "no reaction" if a reaction does not occur.

a. $Fe(s) + Pb(NO_3)_2(aq) \rightarrow$

b. $Cl_2(aq) + NaI(aq) \rightarrow$

c. $Ca(s) + H_2O(l) \rightarrow$

$Fe(s) + Pb(NO_3)_2(aq) \rightarrow$

Analyze

Step 1. Identify the more active metal.

Table 11.2 shows that iron is more reactive than lead.

Solve

Step 2. Write a skeleton equation.

Fe replaces Pb.

$Fe(s) + Pb(NO_3)_2(aq) \rightarrow Pb(s) + Fe(NO_3)_2(aq)$

Step 3. Count to see if the equation is balanced.

Name _____ Class _____ Date _____

$Cl_2(aq) + NaI(aq) \rightarrow$

Analyze

Step 1. Identify relevant concepts.

Cl and I are Group 7A halogens, and Cl is more reactive than I. Recall that chlorine and iodine exist as diatomic molecules.

Solve

Step 2. Write a skeleton equation.

Cl replaces I.

$$Cl_2(aq) + NaI(aq) \rightarrow I_2(aq) + NaCl(aq)$$

Step 3. Balance the equation.

$Cl_2(aq) + 2NaI(aq) \rightarrow I_2(aq) + 2NaCl(aq)$

$Ca(s) + H_2O(l) \rightarrow$

Analyze

Step 1. Identify relevant concepts.

According to Table 11.2, Ca is more reactive than H and can replace H in water. Ca has a 2+ charge and OH has a 1− charge. Also, hydrogen gas exists as a diatomic molecule.

Solve

Step 2. Write a skeleton equation.

The Ca replaces the H.

$$Ca(s) + 2H_2O(l) \rightarrow 2H_2(g) + Ca(OH)_2(aq)$$

Step 3. Balance the equation.

$Ca(s) + 2H_2O(l) \rightarrow 2H_2(g) + Ca(OH)_2(aq)$

Name _____ Class _____ Date _____

Answer the following questions about Practice Problem 16a and b.

Write the products of these double-replacement reactions. Balance each equation.

a. $NaOH(aq) + Fe(NO_3)_3(aq) \rightarrow$ (Iron(III) hydroxide is a precipitate.)

b. $Ba(NO_3)_2(aq) + H_3PO_4(aq) \rightarrow$ (Barium phosphate is a precipitate.)

$NaOH(aq) + Fe(NO_3)_3(aq) \rightarrow$

Analyze

Step 1. Write the formula for iron(III) hydroxide.

$Fe(OH)_3$

Solve

Step 2. Write the skeleton equation.

$$NaOH(aq) + Fe(NO_3)_3(aq) \rightarrow Fe(OH)_3(s) + NaNO_3(aq)$$

Step 3. Balance the equation.

$3NaOH(aq) + Fe(NO_3)_3(aq) \rightarrow Fe(OH)_3(s) + 3NaNO_3(aq)$

$Ba(NO_3)_2(aq) + H_3PO_4(aq) \rightarrow$

Analyze

Step 1. Write the formula for barium phosphate.

$Ba_3(PO_4)_2$

Solve

Step 2. Write the skeleton equation.

$$Ba(NO_3)_2(aq) + H_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + HNO_3(aq)$$

Step 3. Balance the equation.

$3Ba(NO_3)_2(aq) + 2H_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + 6HNO_3(aq)$

Name _____ Class _____ Date _____

Answer the following questions about Practice Problem 19a.

Write a balanced equation for the complete combustion of glucose ($C_6H_{12}O_6$).

Analyze

Step 1. Identify the second reactant and the products.

Oxygen gas is the other reactant in a combustion reaction. The products are CO_2 and H_2O.

Step 2. Write a skeleton equation for this reaction.

$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$

Solve

Step 3. Balance the equation.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Apply the Big idea

One way geologists identify rocks that contain the carbonate ion is to place acid on them. If the rock is a carbonate, then H_2O, bubbles of CO_2, and another compound form. Answer these questions for a reaction between HCl and $CaCO_3$, the main component of limestone.

1. This reaction is not a single reaction. Write a balanced chemical equation for each step of the reaction.

   a. the double-replacement reaction between HCl and $CaCO_3$

   $2HCl + CaCO_3 \rightarrow CaCl_2 + H_2CO_3$

   b. the decomposition of one of the products of the previous reaction

   $H_2CO_3 \rightarrow H_2O + CO_2$

2. Write a balanced equation that shows the initial reactants and the final products of the reaction.

   $2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$

Name _____ Class _____ Date _____

11 Self-Check Activity

For Questions 1–12, complete each statement by writing the correct word or words. If you need help, you can go online.

11.1 Describing Chemical Reactions

1. To write a word equation, the ***names*** of the reactants are on the left side of the arrow, and those of the products are on the right side.

2. To write a skeleton equation, the ***formulas*** of the reactants are on the left side of the arrow, and those of the products are on the right side.

3. Use ***coefficients*** to balance a skeleton equation so that it obeys the law of ***conservation of mass***.

11.2 Types of Chemical Reactions

4. There are ***five*** general types of reactions.

5. The type of reaction is indicated by the number and type of ***reactants*** and products.

6. In a(n) ***combination*** reaction, there are more than one reactant and a single product.

7. In a(n) ***decomposition*** reaction, a compound breaks down into two or more products.

8. In a(n) ***single-replacement*** reaction, the reactants are a compound and an element, and the products are a different compound and element.

9. A(n) ***double-replacement*** reaction takes place between two compounds in aqueous solution.

10. Oxygen is always a reactant in a(n) ***combustion*** reaction.

11.3 Reactions in Aqueous Solution

11. A(n) ***net ionic*** equation shows only the particles present that are involved in the reaction.

12. By examining solubility, you can predict whether a(n) ***precipitate*** forms during a reaction.

If You Have Trouble With...												
Question	1	2	3	4	5	6	7	8	9	10	11	12
See Page	348	348	350	356	356	356	358	360	362	363	370	371

Name _____ Class _____ Date _____

Review Vocabulary

Magnesium chloride and sodium phosphate undergo a double-replacement reaction when the solutions are mixed. Match each of the ways to express this reaction with the name of the type of equation. Use each choice only once.

Types of equations:

a. balanced equation
b. complete ionic equation
c. skeleton equation
d. net ionic equation
e. word equation

d **1.** $3Mg^{2+} + 2PO_4^{3-} \rightarrow Mg_3(PO_4)_2$

a **2.** $3MgCl_2 + 2Na_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6NaCl$

e **3.** magnesium chloride + sodium phosphate → magnesium phosphate + sodium chloride

c **4.** $MgCl_2 + Na_3PO_4 \rightarrow Mg_3(PO_4)_2 + NaCl$

b **5.** $3Mg^{2+} + 6Cl^- + 6Na^+ + 2PO_4^{3-} \rightarrow Mg_3(PO_4)_2 + 6Na^+ + 6Cl^-$

Match each equation with the type of reaction it represents. You may use each type more than once. If a reaction meets the requirements of more than one type of reaction, list all types.

Types of reactions:

a. combustion
b. combination
c. decomposition
d. double-replacement
e. single-replacement

a, b **1.** $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

d **2.** $(NH_4)_2SO_4(aq) + Ba(NO_3)_2(aq) \rightarrow BaSO_4(s) + 2NH_4NO_3(aq)$

b **3.** $H_2O(l) + CO_2(g) \rightarrow H_2CO_3(aq)$

e **4.** $Ca(s) + 2CuNO_3(aq) \rightarrow 2Cu(s) + Ca(NO_3)_2(aq)$

c **5.** $2NaCl(l) \xrightarrow{\text{electricity}} 2Na(s) + Cl_2(g)$