

# Types of Chemical Reactions

## Section Review 8.2

**DIRECTIONS:** Write on the line at the right of each statement the letter preceding the word or expression that best completes the statement.

1. The reaction  $2\text{Mg(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{MgO(s)}$  is an example of a(n) (a) synthesis reaction; (b) decomposition reaction; (c) single-replacement reaction; (d) double-replacement reaction. \_\_\_\_\_ 1
2. The reaction  $\text{Mg(s)} + \text{HCl(aq)} \rightarrow \text{H}_2\text{(g)} + \text{MgCl}_2\text{(aq)}$  is an example of a(n) (a) combustion reaction; (b) decomposition reaction; (c) single-replacement reaction; (d) double-replacement reaction. \_\_\_\_\_ 2
3. The equation  $2\text{HgO(s)} \rightarrow 2\text{Hg(l)} + \text{O}_2\text{(g)}$  is an example of a(n) (a) single-replacement reaction; (b) synthesis reaction; (c) ionic reaction; (d) decomposition reaction. \_\_\_\_\_ 3
4. In one type of synthesis reaction, an element combines with oxygen to yield a(n) (a) acid; (b) hydroxide; (c) oxide; (d) metal. \_\_\_\_\_ 4
5. A metal carbonate, when heated, decomposes into a metal oxide and (a) carbon; (b) carbon dioxide; (c) oxygen; (d) hydrogen. \_\_\_\_\_ 5
6. In the equation  $2\text{Al(s)} + 3\text{Fe(NO}_3)_2\text{(aq)} \rightarrow 3\text{Fe(s)} + 2\text{Al(NO}_3)_3\text{(aq)}$ , iron has been replaced by (a) nitrate; (b) water; (c) aluminum; (d) nitrogen. \_\_\_\_\_ 6
7. The replacement of bromine by chlorine in a salt is an example of a single-replacement reaction by (a) halogens; (b) sodium; (c) water; (d) electrolysis. \_\_\_\_\_ 7
8. The reaction of calcium oxide (CaO) with water will yield (a) calcium and oxygen gas; (b) calcium hydroxide; (c) calcium and a salt; (d) carbon dioxide and water. \_\_\_\_\_ 8
9. Predict the product of the following reaction.  $\text{MgO} + \text{CO}_2 \rightarrow$  (a)  $\text{MgCO}_3$  (b)  $\text{Mg} + \text{CO}_3$  (c)  $\text{MgC} + \text{O}_3$  (d)  $\text{MgCO}_2 + \text{O}$  \_\_\_\_\_ 9
10. What product(s) will result from the decomposition of HgO? (a) mercury(I) oxide (b) mercury and oxygen (c) mercury hydroxide (d) only mercury \_\_\_\_\_ 10

**DIRECTIONS:** Write on the line at the right of each statement the word or expression that best completes the meaning when substituted for the corresponding number.

11. A reaction in which two or more substances combine to form a new substance is called a(n) \_\_\_\_\_ 11  
    (11) reaction.
12. The equation  $\text{AX} \rightarrow \text{A} + \text{B}$  is the general equation for a(n) \_\_\_\_\_ 12  
    (12) reaction.
13. A reaction in which one element replaces a similar element in a compound is called a(n) \_\_\_\_\_ 13  
    (13) reaction.
14. \_\_\_\_\_ 14  
    (14) is the decomposition of a substance by an electric current.
15. Group-1 metals react with water to produce \_\_\_\_\_ 15  
    (15) and metal hydroxides.

## CHAPTER 9 REVIEW ACTIVITY

Text Reference: Section 9-12

## Categories of Chemical Reactions

State whether each of the following equations represents a synthesis (s), analysis (a), single replacement (sr), or double replacement (dr) reaction.

- |  |           |
|--|-----------|
| 1. $\text{CO}_2 \rightarrow \text{C} + \text{O}_2$   | 1. _____  |
| 2. $\text{NaCl} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgCl}$                     | 2. _____  |
| 3. $\text{S} + \text{Cl}_2 \rightarrow \text{SCl}_2$   | 3. _____  |
| 4. $\text{BaCl}_2 + 2\text{NaOH} \rightarrow 2\text{NaCl} + \text{Ba(OH)}_2$                 | 4. _____  |
| 5. $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$                         | 5. _____  |
| 6. $\text{CH}_4 \rightarrow \text{C} + 2\text{H}_2$  | _____     |
| 7. $\text{Pb(NO}_3)_2 + \text{Mg} \rightarrow \text{Pb} + \text{Mg(NO}_3)_2$                 | 7. _____  |
| 8. $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$                          | 8. _____  |
| 9. $\text{H}_2\text{SO}_4 \rightarrow \text{H}_2 + \text{S} + 2\text{O}_2$                   | 9. _____  |
| 10. $2\text{O}_2 + \text{N}_2 \rightarrow \text{N}_2\text{O}_4$                              | 10. _____ |
| 11. $3\text{CaBr}_2 + 2\text{Na}_3\text{P} \rightarrow \text{Ca}_3\text{P}_2 + 6\text{NaBr}$ | 11. _____ |
| 12. $2\text{KI} + \text{Br}_2 \rightarrow 2\text{KBr} + \text{I}_2$                          | 12. _____ |
| 13. $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 6\text{C} + 6\text{H}_2\text{O}$          | 13. _____ |
| 14. $2\text{NaF} \rightarrow 2\text{Na} + \text{F}_2$  | 14. _____ |
| 15. $\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$  | 15. _____ |
| 16. $2\text{NaI} + \text{Pb(NO}_3)_2 \rightarrow 2\text{NaNO}_3 + \text{PbI}_2$              | 16. _____ |
| 17. $\text{NaI} + \text{Cs} \rightarrow \text{CsI} + \text{Na}$                              | 17. _____ |
| 18. $\text{H}_2 + \text{CO} + \text{O}_2 \rightarrow \text{H}_2\text{CO}_3$                  | 18. _____ |
| 19. $\text{Li}_3\text{PO}_4 \rightarrow 3\text{Li} + \text{P} + 2\text{O}_2$                 | 19. _____ |
| 20. $\text{CS}_2 + 2\text{F}_2 \rightarrow \text{CF}_4 + 2\text{S}$                          | 20. _____ |

# Chemical Equations

## Section Review 8.1

**DIRECTIONS:** Write on the line at the right of each statement the letter preceding the word or expression that best completes the statement.

1. The actual knowledge about what products are produced in a chemical reaction is obtained by (a) inspecting the chemical equation; (b) balancing the chemical equation; (c) laboratory analysis; (d) writing a word equation. \_\_\_\_\_ 1
2. Once the correct formula for a reactant in an equation has been written, the (a) subscripts are adjusted to balance the equation; (b) formula should not be changed; (c) same formula must appear as a product; (d) symbols used in the formula must not be used on the product side of the equation. \_\_\_\_\_ 2
3. In writing an equation in which hydrogen gas appears as a product, the correct representation of hydrogen gas is (a) H; (b) 2H; (c) H<sub>2</sub>; (d) OH. \_\_\_\_\_ 3
4. In a chemical equation, the symbol "→" is read (a) aqueous; (b) goes; (c) yields; (d) points. \_\_\_\_\_ 4
5. In a chemical equation, the upward pointing arrow is used for a(n) (a) heated reactant; (b) gaseous reactant; (c) catalyst; (d) gaseous product. \_\_\_\_\_ 5
6. How would oxygen be represented in the formula equation for the reaction of methane and oxygen to yield carbon dioxide and water? (a) oxygen (b) O (c) O<sub>2</sub> (d) O<sub>3</sub> \_\_\_\_\_ 6
7. What is the ratio of hydrogen to chlorine in the equation H<sub>2</sub>(g) + Cl<sub>2</sub>(g) → 2HCl(g)? (a) 1:2 (b) 2:1 (c) 1:1 (d) 4:2 \_\_\_\_\_ 7
8. Balanced formula equations express all of the following EXCEPT (a) experimentally established facts; (b) mechanisms by which reactants become restructured into products; (c) identities of reactants and products in a chemical system; (d) relative quantities of reactants and products in the system. \_\_\_\_\_ 8
9. A reversible reaction is indicated by (a) a capital R; (b) a lower-case r; (c) an up and down arrow; (d) two yield symbols pointing in opposite directions. \_\_\_\_\_ 9
10. When the equation Fe<sub>3</sub>O<sub>4</sub> + Al → Al<sub>2</sub>O<sub>3</sub> + Fe is correctly balanced, the coefficient of Fe is (a) 3; (b) 4; (c) 6; (d) 9. \_\_\_\_\_ 10

**DIRECTIONS:** Write the answers to the following on the lines provided. Where appropriate, make complete statements.

11. In a chemical equation, the symbol "(s)" indicates that the substance is a(n) \_\_\_\_\_. 11
12. Write the word equation that represents the production of water from hydrogen and oxygen. \_\_\_\_\_  
\_\_\_\_\_ 12

**DIRECTIONS:** Write the answers to the following in the space provided.

13. Write the formula equation for the formation of carbon dioxide from carbon and oxygen. \_\_\_\_\_ 13
14. Balance the formula equation NH<sub>4</sub>NO<sub>2</sub> → N<sub>2</sub>(g) + H<sub>2</sub>O. \_\_\_\_\_ 14
15. Balance the formula equation CaO + H<sub>2</sub>O → Ca(OH)<sub>2</sub>. \_\_\_\_\_ 15



# Activity 3-8

## Chemical Equations I

### Introduction

A chemical equation is a concise statement of facts about a chemical reaction. It always identifies the reactants and products and gives the relative numbers of atoms, ions, and molecules involved in the reaction. It may also include additional information about energy changes and phase.

The equation below describes the burning of methane, the primary component of natural gas.



1. The names of the reactants are \_\_\_\_\_ and \_\_\_\_\_.

The names of the products are \_\_\_\_\_ and \_\_\_\_\_.

2. Several ratios of molecules can be determined from the equation. Write numbers in the blanks to indicate the ratios of molecules.

_____ molecule(s) $\text{O}_2$	_____ molecule(s) $\text{O}_2$	_____ molecule(s) $\text{CO}_2$
_____ molecule(s) $\text{CH}_4$	_____ molecule(s) $\text{H}_2\text{O}$	_____ molecule(s) $\text{CH}_4$

3. Why is the equation above a balanced equation? Choose *a* or *b* for your answer and circle the letter of your choice.
- a. The total number of molecules of reactants is equal to the total number of molecules of products.
  - b. For each element, the number of atoms represented as reactants is equal to the number of atoms represented as products.
4. Is the equation below balanced? \_\_\_\_\_



Account for your answer. \_\_\_\_\_

Notice that six molecules of reactants are changed into one molecule of product. Is this consistent with the law of conservation of mass? Account for your answer. \_\_\_\_\_

5. How many different oxygen atoms are represented in the equation in question 4? \_\_\_\_\_ The correct answer is 10 (not 20). Account for the correct answer.

## Writing balanced chemical equations

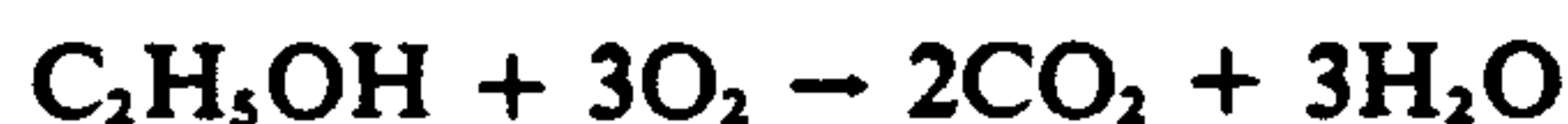
Writing balanced chemical equations is a three-step process:

- Identify or name each of the reactants and products. They may be elements, ionic compounds, or molecular compounds.
- Write the *correct* formula for each reactant and product. These formulas may be simply the symbol for an uncombined atom or they may be empirical or molecular formulas for compounds.
- Adjust the coefficients in the equation to maintain conservation of atoms. Be careful not to confuse subscript numerals inside formulas with the coefficients that precede the formulas in the equation.

6. Balance the following equations by adjusting the coefficients to maintain conservation of atoms. Note that the correct chemical formulas for reactants and products have been provided. Water is sometimes written as HOH when hydroxide compounds are involved in chemical change. Usually when a coefficient is determined to be "1", no numeral is written. However, throughout this unit we may use the numeral "1" to help in balancing.

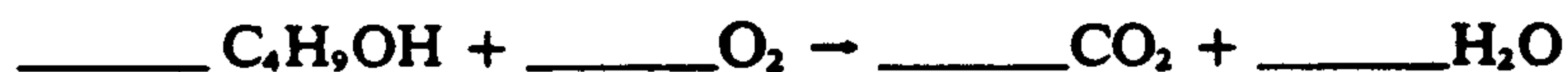
- a. \_\_\_\_\_  $\text{HCl}$  + \_\_\_\_\_  $\text{Ca(OH)}_2$   $\rightarrow$  \_\_\_\_\_  $\text{CaCl}_2$  + \_\_\_\_\_  $\text{HOH}$   
b. \_\_\_\_\_  $\text{Fe}$  + \_\_\_\_\_  $\text{Cl}_2$   $\rightarrow$  \_\_\_\_\_  $\text{FeCl}_3$   
c. \_\_\_\_\_  $\text{Mg}$  + \_\_\_\_\_  $\text{N}_2$   $\rightarrow$  \_\_\_\_\_  $\text{Mg}_3\text{N}_2$   
d. \_\_\_\_\_  $\text{FeCl}_3$  + \_\_\_\_\_  $\text{Na}_3\text{PO}_4$   $\rightarrow$  \_\_\_\_\_  $\text{Fe}_3(\text{PO}_4)_2$  + \_\_\_\_\_  $\text{NaCl}$   
e. \_\_\_\_\_  $\text{AgNO}_3$  + \_\_\_\_\_  $\text{AlCl}_3$   $\rightarrow$  \_\_\_\_\_  $\text{AgCl}$  + \_\_\_\_\_  $\text{Al(NO}_3)_3$

7. Ethyl alcohol ( $\text{C}_2\text{H}_5\text{OH}$ ) burns to form carbon dioxide and water, as follows:



Do the coefficients used give a balanced equation? \_\_\_\_\_ Account for your answer. \_\_\_\_\_

8. Butyl alcohol ( $\text{C}_4\text{H}_9\text{OH}$ ) burns to form the same products. Balance the equation below by adjusting the coefficients to maintain conservation of atoms.



9. Sodium sulfide will react with copper (II) chloride to form sodium chloride and copper (II) sulfide. Follow the steps above to write a balanced equation for that chemical change.

\_\_\_\_\_

Both reactants and both products are ionic compounds. How many of each kind of ion did you represent?

$\text{Na}^+$  \_\_\_\_\_  $\text{S}^{2-}$  \_\_\_\_\_  $\text{Cu}^{2+}$  \_\_\_\_\_  $\text{Cl}^-$  \_\_\_\_\_

What is the sum of the coefficients of the reactants? \_\_\_\_\_

What is the sum of the coefficients of the products? \_\_\_\_\_

Write formulas for and balance the following:

1. magnesium bromide(aq) + chlorine(g)  $\longrightarrow$  magnesium chloride(aq) + bromine(g)
2. sodium(c) + water(l)  $\longrightarrow$  sodium hydroxide(aq) + hydrogen(g)
3. potassium nitrate(c)  $\longrightarrow$  potassium nitrite(c) + oxygen(g)
4. zinc(c) + hydrochloric acid(aq)  $\longrightarrow$  zinc chloride(aq) + hydrogen(g)
5. calcium oxide(c) + hydrochloric acid(aq)  $\longrightarrow$  calcium chloride(aq) + water(l)

Write balanced equations for each of the following chemical reactions.

6.  $\text{Mg(c)} + \text{O}_2\text{(g)} \longrightarrow \text{MgO(c)}$
7.  $\text{Fe(c)} + \text{O}_2\text{(g)} \longrightarrow \text{Fe}_2\text{O}_3\text{(c)}$
8.  $\text{H}_2\text{O(l)} + \text{N}_2\text{O}_3\text{(g)} \longrightarrow \text{HNO}_2\text{(aq)}$
9.  $\text{Na}_2\text{O(c)} + \text{H}_2\text{O(l)} \longrightarrow \text{NaOH(aq)}$
10.  $\text{Fe(c)} + \text{H}_2\text{O(l)} \longrightarrow \text{Fe}_3\text{O}_4\text{(c)} + \text{H}_2\text{(g)}$

Balance the following equations.

11.  $\text{KClO}_3\text{(c)} \longrightarrow \text{KCl(c)} + \text{O}_2\text{(g)}$
12.  $\text{PbO}_2\text{(c)} \longrightarrow \text{PbO(c)} + \text{O}_2\text{(g)}$
13.  $\text{HgO(c)} \longrightarrow \text{Hg(l)} + \text{O}_2\text{(g)}$
14.  $\text{H}_2\text{O(l)} \longrightarrow \text{H}_2\text{(g)} + \text{O}_2\text{(g)}$
15.  $\text{Al(c)} + \text{Pb(NO}_3)_2\text{(aq)} \longrightarrow \text{Al(NO}_3)_3\text{(aq)} + \text{Pb(c)}$
16.  $\text{Cu(c)} + \text{AgNO}_3\text{(aq)} \longrightarrow \text{Cu(NO}_3)_2\text{(aq)} + \text{Ag(c)}$
17.  $\text{K(c)} + \text{H}_2\text{O(l)} \longrightarrow \text{KOH(aq)} + \text{H}_2\text{(g)}$
18.  $\text{MnO}_2\text{(c)} + \text{HCl(aq)} \longrightarrow \text{MnCl}_2\text{(aq)} + \text{Cl}_2\text{(g)} + \text{H}_2\text{O(l)}$
19.  $\text{Cl}_2\text{(g)} + \text{LiI(aq)} \longrightarrow \text{LiCl(aq)} + \text{I}_2\text{(g)}$
20.  $\text{Ca(OH)}_2\text{(aq)} + \text{HCl(aq)} \longrightarrow \text{CaCl}_2\text{(aq)} + \text{H}_2\text{O(l)}$
21.  $\text{KOH(aq)} + \text{H}_3\text{PO}_4\text{(aq)} \longrightarrow \text{K}_3\text{PO}_4\text{(aq)} + \text{H}_2\text{O(l)}$
22.  $\text{Al(NO}_3)_3\text{(aq)} + \text{H}_2\text{SO}_4\text{(aq)} \longrightarrow \text{Al}_2\text{(SO}_4)_3\text{(aq)} + \text{HNO}_3\text{(aq)}$
23.  $\text{Na}_2\text{SO}_3\text{(aq)} + \text{HCl(aq)} \longrightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{SO}_2\text{(g)}$
24.  $\text{(NH}_4)_2\text{SO}_4\text{(aq)} + \text{KOH(aq)} \longrightarrow \text{K}_2\text{SO}_4\text{(aq)} + \text{NH}_3\text{(g)} + \text{H}_2\text{O(l)}$
25.  $\text{Pb(NO}_3)_2\text{(aq)} + \text{K}_2\text{S(aq)} \longrightarrow \text{PbS(c)} + \text{KNO}_3\text{(aq)}$

# Activity 3-11

## Practice Drill: Chemical Equations

Complete and balance the following equations for chemical reactions. In the space at the right of each equation, identify the category of reaction. Use:

SYN—synthesis  
DEC—decomposition  
SR—single replacement

- |   |           |
|---|-----------|
| 1. _____ $\text{Al}(s)$ + _____ $\text{Br}_2(g)$ $\rightarrow$ _____                        | 1. _____  |
| 2. _____ $\text{O}_2(g)$ + _____ $\rightarrow$ _____ $\text{Fe}_2\text{O}_3(s)$             | 2. _____  |
| 3. _____ $\text{Zn}(s)$ + _____ $\text{HCl}(aq)$ $\rightarrow$ _____ + _____                | 3. _____  |
| 4. _____ $\text{Mg}$ + _____ $\text{H}_3\text{PO}_4$ $\rightarrow$ _____ + _____            | 4. _____  |
| 5. _____ $\text{NH}_4\text{OH}(aq)$ $\rightarrow$ _____ $\text{NH}_3(g)$ + _____            | 5. _____  |
| 6. _____ $\text{Al}_2\text{O}_3(s)$ $\rightarrow$ _____ $\text{Al}(s)$ + _____              | 6. _____  |
| 7. _____ $\text{KClO}_3(s)$ $\rightarrow$ _____ $\text{O}_2(g)$ + _____                     | 7. _____  |
| 8. _____ $\text{K}(s)$ + _____ $\text{HOH}(l)$ $\rightarrow$ _____ + _____ $\text{KOH}(aq)$ | 8. _____  |
| 9. _____ $\text{Ba}(s)$ + _____ $\rightarrow$ _____ $\text{Ba}_3\text{N}_2(s)$              | 9. _____  |
| 10. _____ $\text{Cu}(s)$ + _____ $\rightarrow$ _____ $\text{Cu}_2\text{S}(s)$               | 10. _____ |

Complete and balance the following equations for chemical reactions.

11. \_\_\_\_\_  $\text{AlI}_3(aq)$  + \_\_\_\_\_  $\text{HgCl}_2(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
12. \_\_\_\_\_  $\text{FeCl}_3(aq)$  + \_\_\_\_\_  $\text{H}_3\text{PO}_4(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
13. \_\_\_\_\_  $\text{SnCl}_4(aq)$  + \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_  $\text{NH}_4\text{Cl}(aq)$  + \_\_\_\_\_  $\text{SnS}_2(s)$
14. \_\_\_\_\_  $\text{CaBr}_2(aq)$  + \_\_\_\_\_  $\text{KOH}(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
15. \_\_\_\_\_  $\text{AgNO}_3(aq)$  + \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_  $\text{Ag}_3\text{PO}_4(s)$  + \_\_\_\_\_  $\text{KNO}_3(aq)$
16. \_\_\_\_\_ + \_\_\_\_\_  $\text{Ba}(\text{OH})_2(aq)$   $\rightarrow$  \_\_\_\_\_  $\text{Al}(\text{OH})_3(s)$  + \_\_\_\_\_  $\text{BaCl}_2(aq)$
17. \_\_\_\_\_  $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2(aq)$  + \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_  $\text{CaCO}_3(s)$  + \_\_\_\_\_  $\text{NaC}_2\text{H}_3\text{O}_2(aq)$
18. \_\_\_\_\_  $\text{Na}_3\text{PO}_4(aq)$  + \_\_\_\_\_  $\text{ZnSO}_4(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
19. \_\_\_\_\_  $\text{Ba}(\text{ClO}_3)_2(aq)$  + \_\_\_\_\_  $\text{Na}_2\text{S}(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
20. \_\_\_\_\_ + \_\_\_\_\_  $\text{AlCl}_3(aq)$   $\rightarrow$  \_\_\_\_\_  $\text{KCl}(aq)$  + \_\_\_\_\_  $\text{Al}_2(\text{CrO}_4)_3(s)$
21. \_\_\_\_\_  $(\text{NH}_4)_2\text{CO}_3(aq)$  + \_\_\_\_\_  $\text{NaOH}(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_  $\text{NH}_3(g)$   
+ \_\_\_\_\_
22. \_\_\_\_\_  $\text{K}_2\text{SO}_3(aq)$  + \_\_\_\_\_  $\text{HNO}_3(aq)$   $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_ + \_\_\_\_\_  $\text{H}_2\text{O}(l)$
23. \_\_\_\_\_ + \_\_\_\_\_  $\text{HNO}_3(aq)$   $\rightarrow$  \_\_\_\_\_  $\text{Ca}(\text{NO}_3)_2(aq)$  + \_\_\_\_\_  $\text{H}_2\text{O}(l)$
24. \_\_\_\_\_  $\text{Hg}_2(\text{NO}_3)_2(aq)$  + \_\_\_\_\_  $(aq)$   $\rightarrow$  \_\_\_\_\_  $\text{Hg}_2\text{I}_2(s)$  + \_\_\_\_\_  $\text{NaNO}_3(aq)$

To which category do all these reactions belong? \_\_\_\_\_



Write balanced chemical equations for each of the following double replacement reactions.

25. calcium iodide + sulfuric acid →

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26. manganese sulfide + lead (IV) chloride →

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27. potassium hydroxide + iron (III) chloride →

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28. zinc bromide + sodium carbonate →

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29. calcium hydroxide + mercuric chloride →

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30. barium carbonate + sulfuric acid →

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31. potassium hydroxide + ammonium sulfate →

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32. sodium sulfite + hydrogen chloride →

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# Activity 3-10

## Categories of Chemical Reactions

Many chemical reactions can be classified into one of these four categories:

- Direct combination or synthesis.
- Decomposition or analysis.
- Single replacement.
- Double replacement.

### Direct combination or synthesis

A direct combination or synthesis reaction occurs when a compound is prepared from its elements or from simpler compounds.

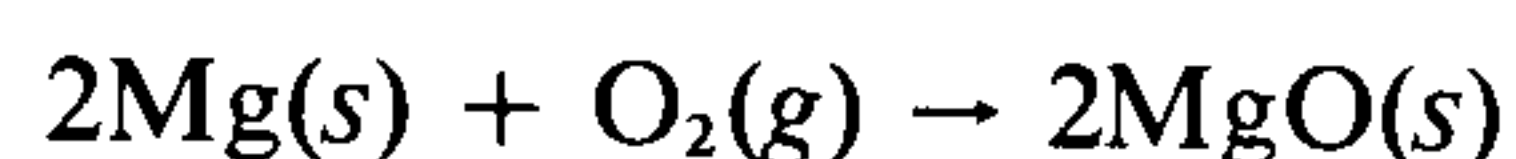
1. What is the definition of *synthesis* as given in a dictionary? \_\_\_\_\_

\_\_\_\_\_

What is the definition of *synthesis* given in the glossary of your textbook? \_\_\_\_\_

\_\_\_\_\_

2. The reaction



is classified as a direct combination or synthesis reaction because the elements \_\_\_\_\_  
and \_\_\_\_\_ react to produce the compound \_\_\_\_\_.

3. The reaction



is classified as a synthesis reaction because \_\_\_\_\_

\_\_\_\_\_

### Decomposition or analysis

A decomposition or analysis reaction occurs when a compound is decomposed into its elements or into simpler compounds.

4. What is the definition of *analysis* as given in a dictionary? \_\_\_\_\_

\_\_\_\_\_

What is the definition of *analysis* as given in the glossary of your textbook? \_\_\_\_\_

\_\_\_\_\_

5. The reaction



is classified as a decomposition or analysis reaction because the compound \_\_\_\_\_  
\_\_\_\_\_ is converted into the simpler compounds \_\_\_\_\_  
and \_\_\_\_\_.

6. The reaction

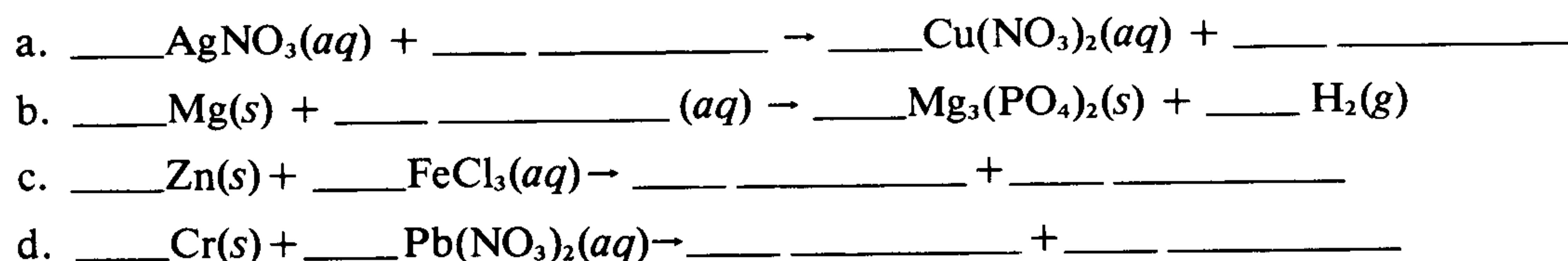


is classified as an analysis reaction because \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

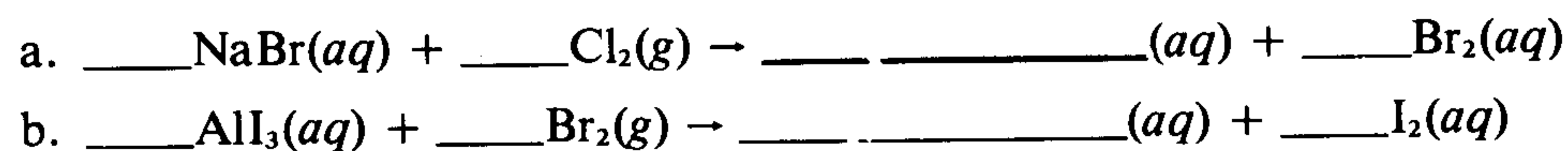
## Single replacement

A single replacement reaction occurs when an element reacts with a compound to produce a different element and a different compound.

7. Some metals can replace other metals or hydrogen from binary and ternary compounds. Complete and balance the following equations for single replacement reactions.



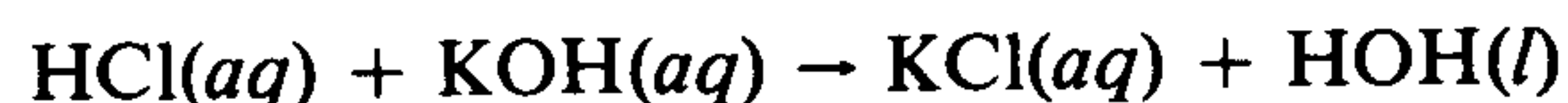
8. Some nonmetals can replace other nonmetals from binary compounds. Complete and balance the following equations for single replacement reactions.



## Double replacement

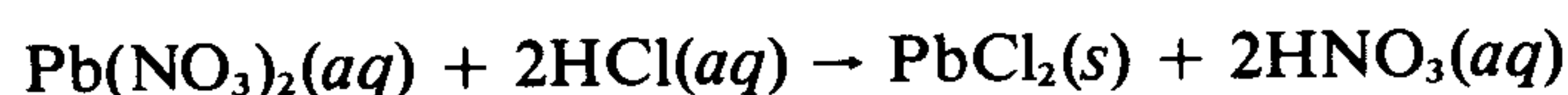
A double replacement reaction may occur when solutions of certain ionic compounds are mixed with each other. If the mixing produces one or more of the following results, a double replacement reaction has taken place.

- The formation of water molecules, usually from the joining of  $\text{H}^+$  and  $\text{OH}^-$  ions, for example:



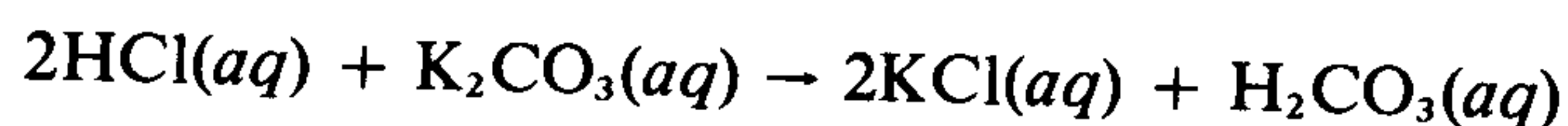
Note how water is written as HOH to emphasize the bonding of  $\text{H}^+$  with  $\text{OH}^-$ .

- The formation of an insoluble product, called a precipitate, which settles out of the reaction mixture into the solid phase, for example:



(Refer to Table C in the Appendix for information.)

- The formation of a gas that escapes from the reaction mixture. Three gases often formed are  $\text{CO}_2$ ,  $\text{SO}_2$ , and  $\text{NH}_3$ . For example, if the reaction:



is carried out in an open test tube or flask, the product  $\text{H}_2\text{CO}_3$  will react further to form  $\text{H}_2\text{O}$  and  $\text{CO}_2$  until all of the  $\text{H}_2\text{CO}_3$  is used up. We can write the equation for the complete reaction as follows:

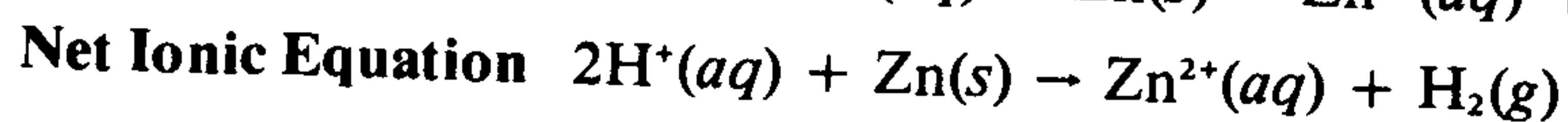
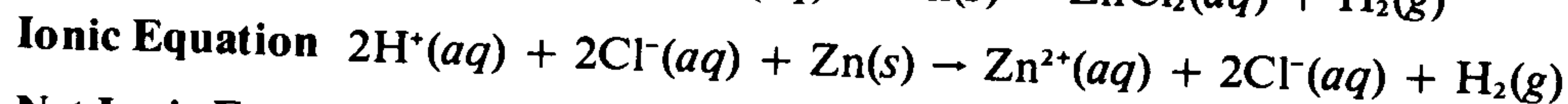
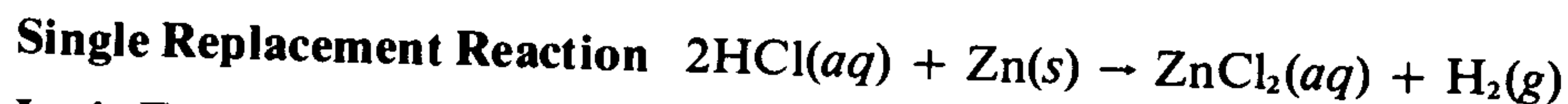


It is convenient to write the formula  $\text{H}_2\text{CO}_3$  to write the equation. However,  $\text{H}_2\text{CO}_3$  should be changed to  $\text{H}_2\text{O}(l) + \text{CO}_2(g)$  in the completed equation. Similarly, when  $\text{H}_2\text{SO}_3$  appears to be the product of a double replacement, it should be written  $\text{H}_2\text{O}(l) + \text{SO}_2(g)$  in the completed equation. Also, when  $\text{NH}_4\text{OH}$  is one of the products, it should be written  $\text{NH}_3(g) + \text{H}_2\text{O}(l)$  in the completed equation.

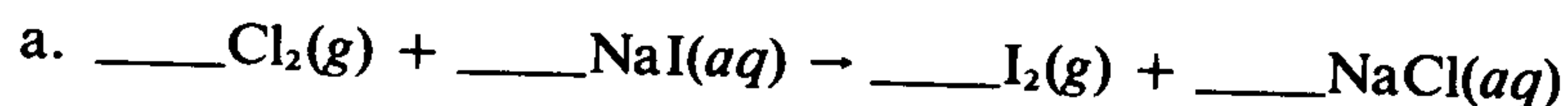
- Complete and balance each of the following double replacement reactions, in which water is a product.
  - \_\_\_\_\_ + \_\_\_\_\_  $\text{KOH}(aq) \rightarrow$  \_\_\_\_\_  $\text{HOH}(l) +$  \_\_\_\_\_  $\text{K}_3\text{PO}_4(aq)$
  - \_\_\_\_\_  $\text{HC}_2\text{H}_3\text{O}_2(aq) +$  \_\_\_\_\_  $\text{Ca}(\text{OH})_2(aq) \rightarrow$  \_\_\_\_\_  $\text{HOH}(l) +$  \_\_\_\_\_
  - \_\_\_\_\_  $\text{HCl}(aq) +$  \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_  $\text{BaCl}_2(aq) +$  \_\_\_\_\_  $\text{HOH}(l)$
- Complete and balance each of the following double replacement reactions, in which an insoluble compound (precipitate) is a product.
  - \_\_\_\_\_  $\text{AgNO}_3(aq) +$  \_\_\_\_\_  $\text{Na}_2\text{CO}_3(aq) \rightarrow$  \_\_\_\_\_  $(s) +$  \_\_\_\_\_  $\text{NaNO}_3(aq)$
  - \_\_\_\_\_ + \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_  $\text{AlPO}_4(s) +$  \_\_\_\_\_  $\text{KCl}(aq)$
  - \_\_\_\_\_  $\text{BaCl}_2(aq) +$  \_\_\_\_\_  $\text{Na}_2\text{CrO}_4(aq) \rightarrow$  \_\_\_\_\_  $(s) +$  \_\_\_\_\_  $\text{NaCl}(aq)$
- Complete and balance each of the following double replacement reactions, in which a gas is produced.
  - \_\_\_\_\_  $\text{Na}_2\text{SO}_3(aq) +$  \_\_\_\_\_  $\text{HNO}_3(aq) \rightarrow$  \_\_\_\_\_ + \_\_\_\_\_  $(g) +$  \_\_\_\_\_  $\text{H}_2\text{O}(l)$
  - \_\_\_\_\_  $(\text{NH}_4)_3\text{PO}_4(aq) +$  \_\_\_\_\_  $\text{KOH}(aq) \rightarrow$  \_\_\_\_\_ + \_\_\_\_\_  $\text{H}_2\text{O}(l) +$  \_\_\_\_\_  $(g)$
  - \_\_\_\_\_ + \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_  $\text{CO}_2(g) +$  \_\_\_\_\_  $\text{H}_2\text{O}(l) +$  \_\_\_\_\_  $\text{ZnCl}_2(aq)$

## Ionic equations

In many chemical reactions, some or all of the reactants and products may be ions, rather than molecules or atoms. Equations for single replacement and double replacement reactions are often written as ionic equations. Ionic equations can then be converted into net ionic equations by the omission of spectator ions.

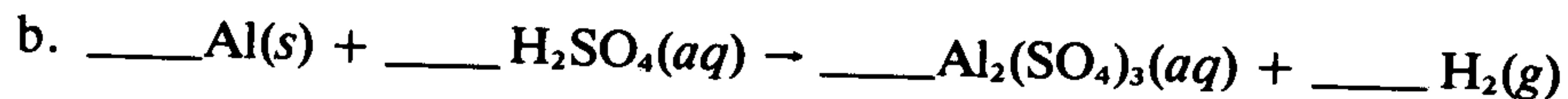


12. For each reaction below, balance the single replacement equation and convert it into ionic and net ionic equations.



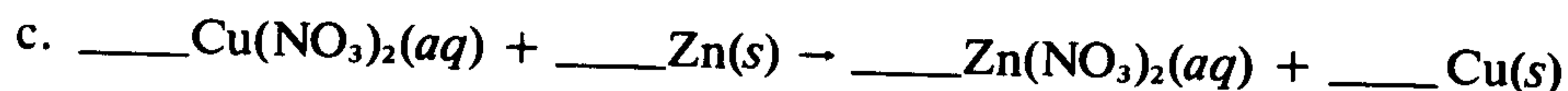
Ionic equation \_\_\_\_\_

Net ionic equation \_\_\_\_\_



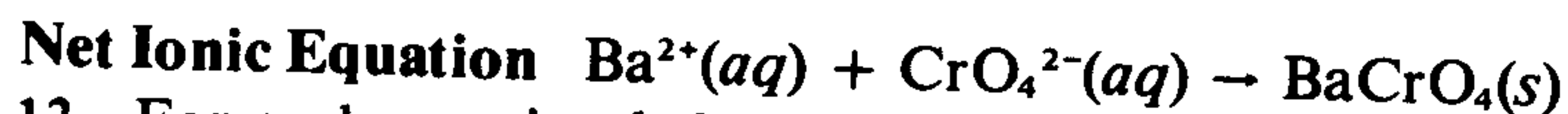
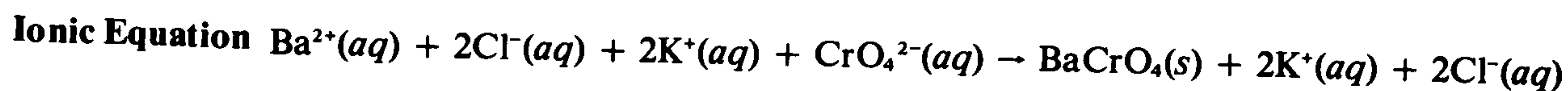
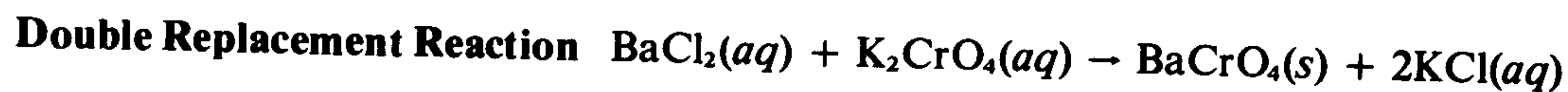
Ionic equation \_\_\_\_\_

Net ionic equation \_\_\_\_\_

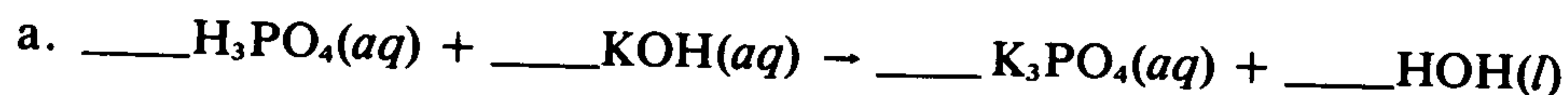


Ionic equation \_\_\_\_\_

Net ionic equation \_\_\_\_\_

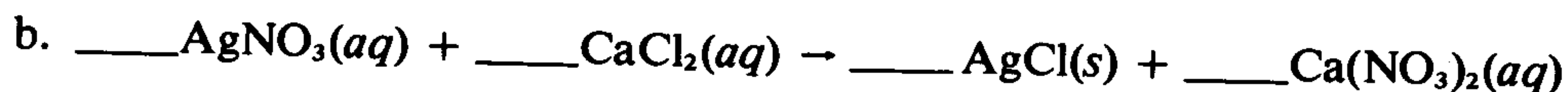


13. For each reaction below, balance the double replacement equation and convert it into ionic and net ionic equations.



Ionic equation \_\_\_\_\_

Net ionic equation \_\_\_\_\_



Ionic equation \_\_\_\_\_

Net ionic equation \_\_\_\_\_



Ionic equation \_\_\_\_\_

Net ionic equation \_\_\_\_\_



# Equations

Write a balanced chemical equation to represent each of the following chemical reactions:

*also identify each type of Rxn as synthesis, combustion, decomposition, single replacement, or double replacement*

1. iron + sulfur  $\rightarrow$  iron (II) sulfide
2. zinc + cupric sulfate  $\rightarrow$  zinc sulfate + copper
3. silver nitrate + sodium bromide  $\rightarrow$  sodium nitrate + silver bromide
4. potassium chlorate (heated)  $\rightarrow$  potassium chloride + oxygen
5. water (electricity)  $\rightarrow$  hydrogen + oxygen
6. mercury (II) oxide (heated)  $\rightarrow$  mercury + oxygen
7. potassium iodide + lead (II) nitrate  $\rightarrow$  lead (II) iodide + potassium nitrate
8. aluminum + oxygen  $\rightarrow$  aluminum oxide
9. magnesium chloride + ammonium nitrate  $\rightarrow$  magnesium nitrate + ammonium chloride
10. iron (III) chloride + ammonium hydroxide  $\rightarrow$  iron (III) hydroxide + ammonium chloride
11. sodium peroxide + water  $\rightarrow$  sodium hydroxide + oxygen
12. iron (III) oxide + carbon  $\rightarrow$  iron + carbon monoxide
13. iron + water  $\rightarrow$  hydrogen + iron (III) oxide
14. iron (III) chloride + potassium hydroxide  $\rightarrow$  potassium chloride + iron (III) hydroxide
15. aluminum + sulfuric acid  $\rightarrow$  aluminum sulfate + hydrogen

(continued)

16. sodium carbonate + calcium hydroxide  $\rightarrow$  sodium hydroxide + calcium carbonate

17. carbon dioxide + water  $\rightarrow$  carbonic acid

18. phosphorus + oxygen  $\rightarrow$  phosphorus pentoxide

19. sodium + water  $\rightarrow$  sodium hydroxide + hydrogen

20. zinc + sulfuric acid  $\rightarrow$  zinc sulfate + hydrogen

21. aluminum sulfate + calcium hydroxide  $\rightarrow$  aluminum hydroxide + calcium sulfate

22. calcium oxide + water  $\rightarrow$  calcium hydroxide

23. iron + copper (I) nitrate  $\rightarrow$  iron (II) nitrate + copper

24. iron (II) sulfide + hydrochloric acid  $\rightarrow$  hydrogen sulfide + iron (II) chloride

25. potassium oxide + water  $\rightarrow$  potassium hydroxide

26. ammonium sulfide + lead (II) nitrate  $\rightarrow$  ammonium nitrate + lead (II) sulfide

27. mercury (II) hydroxide + phosphoric acid  $\rightarrow$  mercury (II) phosphate + water

28. potassium hydroxide + phosphoric acid  $\rightarrow$  potassium phosphate + water

29. calcium chloride + nitric acid  $\rightarrow$  calcium nitrate + hydrochloric acid

30. potassium carbonate + barium chloride  $\rightarrow$  potassium chloride + barium carbonate

31. magnesium hydroxide + sulfuric acid  $\rightarrow$  magnesium sulfate + water

32. sulfur dioxide + water  $\rightarrow$  sulfurous acid

(continued)

33. sodium carbonate + hydrochloric acid  $\rightarrow$  sodium chloride + water + carbon dioxide
34. magnesium + nitric acid  $\rightarrow$  magnesium nitrate + hydrogen
35. aluminum + iron (III) oxide  $\rightarrow$  aluminum oxide + iron
36. potassium phosphate + magnesium chloride  $\rightarrow$  magnesium phosphate + potassium chloride
37. ammonia + oxygen  $\rightarrow$  nitrogen + water
38. calcium carbonate (heated)  $\rightarrow$  calcium oxide + carbon dioxide
39. sodium chloride + sulfuric acid  $\rightarrow$  sodium sulfate + hydrochloric acid
40. fluorine + sodium hydroxide  $\rightarrow$  sodium fluoride + oxygen + water
41. magnesium nitrate + calcium iodide  $\rightarrow$  calcium nitrate + magnesium iodide
42. aluminum sulfate + ammonium bromide  $\rightarrow$  aluminum bromide + ammonium sulfate
43. potassium fluoride + barium bromide  $\rightarrow$  barium fluoride + potassium bromide
44. copper (II) nitrate + ammonium hydroxide  $\rightarrow$  copper (II) hydroxide + ammonium nitrate
45. sodium nitrate (heated)  $\rightarrow$  sodium nitrite + oxygen
46. lead (II) hydroxide (heated)  $\rightarrow$  lead (II) monoxide + water
47. ammonia + sulfuric acid  $\rightarrow$  ammonium sulfate
48. hydrochloric acid + ammonia  $\rightarrow$  ammonium chloride
49. copper (II) sulfate + iron  $\rightarrow$  iron (II) sulfate + copper

(continued)

- 
50. aluminum + hydrochloric acid  $\rightarrow$  aluminum chloride + hydrogen
51. carbon + oxygen  $\rightarrow$  carbon dioxide
52. calcium bicarbonate + calcium hydroxide  $\rightarrow$  calcium carbonate + water
53. hydrogen sulfide + oxygen  $\rightarrow$  water + sulfur
54. sodium hydroxide + calcium nitrate  $\rightarrow$  sodium nitrate + calcium hydroxide
55. potassium iodide + chlorine  $\rightarrow$  potassium chloride + iodine
56. sulfuric acid + potassium hydroxide  $\rightarrow$  potassium sulfate + water
57. carbon dioxide + carbon  $\rightarrow$  carbon monoxide
58. calcium sulfate + sodium carbonate  $\rightarrow$  calcium carbonate + sodium sulfate
59. water + diphosphorus pentoxide  $\rightarrow$  phosphorus acid
60. aluminum + phosphoric acid  $\rightarrow$  hydrogen + aluminum phosphate
61. ammonium chloride + sodium nitrite  $\rightarrow$  sodium chloride + nitrogen + water
62. chlorine + sodium hydroxide  $\rightarrow$  sodium chloride + sodium hypochlorite + water
63. lead (II) nitrate (heated)  $\rightarrow$  lead ~~nitrate~~ <sup>(II) oxide</sup> + nitrogen dioxide + oxygen
64. mercury (I) oxide + oxygen  $\rightarrow$  mercury (II) oxide
65. calcium oxide + magnesium chloride  $\rightarrow$  magnesium oxide + calcium chloride
66. calcium + water  $\rightarrow$  calcium hydroxide + hydrogen

(continued)



67. chromium (III) chloride + sulfuric acid  $\rightarrow$  chromium (III) sulfate + hydrochloric acid
68. iron (III) nitrate + ammonium hydroxide  $\rightarrow$  iron (III) hydroxide + ammonium nitrate
69. aluminum chloride + potassium phosphate  $\rightarrow$  aluminum phosphate + potassium chloride
70. aluminum oxide + carbon + chlorine  $\rightarrow$  carbon monoxide + aluminum chloride
71. copper (I) oxide + hydrochloric acid  $\rightarrow$  copper (I) chloride + water
72. magnesium bicarbonate + hydrochloric acid  $\rightarrow$  magnesium chloride + water + carbon dioxide
73. iron + oxygen  $\rightarrow$  iron (III) oxide
74. silicon + water (heat)  $\rightarrow$  silicon dioxide + hydrogen
75. iron (III) oxide + carbon monoxide  $\rightarrow$  iron + carbon dioxide
76. calcium chloride + chromium (III) nitrate  $\rightarrow$  calcium nitrate + chromium (III) chloride
77. zinc sulfide + oxygen  $\rightarrow$  zinc oxide + sulfur dioxide
78. calcium phosphate + sulfuric acid  $\rightarrow$  calcium sulfate + phosphoric acid
79. iron (III) hydroxide (heated)  $\rightarrow$  iron (III) oxide + water
80. aluminum sulfate + sodium bicarbonate  $\rightarrow$  aluminum hydroxide + sodium sulfate + carbon dioxide
81. calcium phosphate + silicon dioxide + carbon  $\rightarrow$  phosphorus + calcium silicate + carbon monoxide
82. calcium oxide + sulfur dioxide  $\rightarrow$  calcium sulfite

(continued)

- 
83. carbon dioxide + magnesium hydroxide → magnesium carbonate + water
84. calcium oxide + hydrochloric acid → calcium chloride + water
85. calcium carbonate + silicon dioxide → calcium silicate + carbon dioxide
86. antimony + chlorine → antimony trichloride
87. magnesium nitride + water → magnesium hydroxide + ammonia
88. arsenic + oxygen → arsenic (III) oxide
89. ammonium bicarbonate (heated) → ammonia + water + carbon dioxide
90. cupric oxide + ammonia → copper + water + nitrogen
91. ammonium dichromate (heated) → chromium trioxide + nitrogen + water
92. hydrogen sulfide + cadmium nitrate → nitric acid + cadmium sulfide
93. barium bromide + sodium phosphate → barium phosphate + sodium bromide
94. aluminum chloride + ammonium fluoride → aluminum fluoride + ammonium chloride
95. silver nitrate + potassium sulfate → silver sulfate + potassium nitrate
96. bismuth nitrate + calcium iodide → bismuth iodide + calcium nitrate
97. aluminum chromate + ammonium sulfate → ammonium chromate + aluminum sulfate
98. zinc nitrate + ammonium bromide → zinc bromide + ammonium nitrate
99. bismuth nitrate + ammonium hydroxide → bismuth hydroxide + ammonium nitrate

(continued)

100. cadmium nitrate + sulfuric acid  $\rightarrow$  cadmium sulfate + nitric acid
101. zinc + silver iodide  $\rightarrow$  zinc iodide + silver
102. iron (III) chloride + sulfuric acid  $\rightarrow$  iron (III) sulfate + hydrochloric acid
103. bismuth sulfate + ammonium hydroxide  $\rightarrow$  bismuth hydroxide + ammonium sulfate
104. hydrogen iodide + oxygen  $\rightarrow$  iodine + water
105. potassium sulfate + barium chloride  $\rightarrow$  barium sulfate + potassium chloride
106. barium sulfate + carbon  $\rightarrow$  barium sulfide + carbon monoxide
107. aluminum oxide + hydrofluoric acid  $\rightarrow$  aluminum fluoride + water
108. aluminum fluoride + sulfuric acid  $\rightarrow$  aluminum sulfate + hydrogen fluoride
109. potassium iodide + hydrogen peroxide  $\rightarrow$  potassium hydroxide + iodine
110. zinc + ferric sulfate  $\rightarrow$  zinc sulfate + ferrous sulfate
111. lead (II) sulfide + lead monoxide  $\rightarrow$  lead + sulfur dioxide
112. copper + sulfuric acid  $\rightarrow$  copper (II) sulfate + water + sulfur dioxide
113. aluminum hydroxide (heated)  $\rightarrow$  aluminum oxide + water
114. nitrogen + hydrogen  $\rightarrow$  ammonia
115. sodium carbonate + carbonic acid  $\rightarrow$  sodium bicarbonate
116. silicon dioxide + hydrofluoric acid  $\rightarrow$  water + silicon tetrafluoride

(continued)

- 
117. sodium hypochlorite  $\rightarrow$  sodium chloride + sodium chlorate
118. sodium chlorite + chlorine  $\rightarrow$  sodium chloride + chlorine dioxide
119. methane + sulfur dioxide (heated)  $\rightarrow$  hydrogen sulfide + carbon dioxide + hydrogen
120. tellurous acid  $\rightarrow$  tellurium dioxide + water
121. iron (II) selenide + hydrochloric acid  $\rightarrow$  iron (II) chloride + hydrogen selenide
122. magnesium + nitrogen  $\rightarrow$  magnesium nitride
123. silver cyanide + potassium  $\rightarrow$  potassium cyanide + silver
124. copper (II) sulfate + ammonia  $\rightarrow$  cupriammonia sulfate
125. calcium carbide + nitrogen  $\rightarrow$  calcium cyanamide + carbon
126. calcium cyanamide + water  $\rightarrow$  calcium carbonate + ammonia
127. zinc arsenide + hydrochloric acid  $\rightarrow$  arsine + zinc chloride
128. lead (II) hydroxide + sodium stannite  $\rightarrow$  lead + sodium stannate + water
129. sodium silicate + hydrochloric acid  $\rightarrow$  sodium chloride + silicic acid
130. boron trioxide + magnesium  $\rightarrow$  magnesium oxide + boron
131. iron (II) cyanide + potassium cyanide  $\rightarrow$  potassium ferrocyanide
132. sodium aluminate + ammonium chloride  $\rightarrow$  ammonium aluminum oxide + sodium chloride
133. aluminum hydroxide + sodium hydroxide  $\rightarrow$  sodium aluminate + water

(continued)



134. tungsten + chlorine (300°C) → tungsten hexachloride

135. calcium + ammonia → calcium hydride + nitrogen

136. sodium wolframate + sulfuric acid → sodium sulfate + tungstic acid

137. lithium hydride + water → lithium hydroxide + hydrogen

138. boric acid → tetraboric acid + water

139. zinc hydroxide + potassium hydroxide → potassium zincate + water

140. nickel + carbon monoxide → nickel carbonyl

# Activity Series of the Elements

## Section Review 8.3

**DIRECTIONS:** Write on the line at the right of each statement the letter preceding the word or expression that best completes the statement.

1. The ability of an element to react is referred to as the element's (a) valence; (b) activity; (c) stability; (d) electronegativity. \_\_\_\_\_ 1
2. An element in the activity series can replace any element (a) in the periodic table; (b) below it on the list; (c) above it on the list; (d) in its group. \_\_\_\_\_ 2
3. An activity series is useful because it allows a person to predict (a) whether or not a certain chemical reaction will occur; (b) the amount of energy released by a chemical reaction; (c) the electronegativity values of elements; (d) the melting points of elements. \_\_\_\_\_ 3
4. For a single-replacement reaction, an element will replace from a compound in aqueous solution those elements (a) above it in the activity series; (b) with lower atomic masses; (c) below it in the activity series; (d) with higher atomic numbers. \_\_\_\_\_ 4
5. To replace hydrogen from steam, a metal must be (a) above cobalt in the activity series; (b) below hydrogen in the activity series; (c) a halogen; (d) less reactive than lithium. \_\_\_\_\_ 5
6. In the activity series, any metal above hydrogen reacts with acids, replacing (a) hydrogen; (b) oxygen; (c) chlorine; (d) water. \_\_\_\_\_ 6
7. The synthesis of oxides by reaction with oxygen occurs for any metal in the activity series (a) below platinum; (b) above gold; (c) above silver; (d) below tin. \_\_\_\_\_ 7
8. Oxides are formed only indirectly by metals in the activity series (a) above zinc; (b) below calcium; (c) above tin; (d) below mercury. \_\_\_\_\_ 8
9. In the presence of oxygen ( $O_2$ ), gold can be expected to (a) rapidly form an oxide; (b) slowly form an oxide; (c) not react; (d) rapidly form a metallic hydroxide. \_\_\_\_\_ 9
10. In the activity series, oxides of metals below copper (a) do not exist; (b) do not decompose; (c) decompose with heat alone; (d) are acidic. \_\_\_\_\_ 10
11. In the activity series, oxides of metals below chromium yield metals when (a) heated with hydrogen; (b) cooled below  $0^\circ C$ ; (c) combined with oxygen; (d) added to acids. \_\_\_\_\_ 11
12. Since mercury is below copper in the activity series, heating  $HgO$  will result in (a) no reaction; (b) the formation of a hydroxide; (c) the formation of  $Hg_2O$ ; (d) decomposition. \_\_\_\_\_ 12
13. Predict what will happen when calcium metal is added to a solution of magnesium chloride. (a) No reaction will occur. (b) Calcium chloride will form. (c) Magnesium calcite will form. (d) Gaseous calcium will be produced. \_\_\_\_\_ 13
14. Predict what will happen when zinc is added to water. (a) No reaction will occur. (b) Steam will be produced. (c) Zinc oxide will form. (d) Hydrogen will be released. \_\_\_\_\_ 14
15. Predict what will happen when lead is added to nitric acid. (a) No reaction will occur. (b) Oxygen will be released. (c) Lead oxide will form. (d) Hydrogen will be released. \_\_\_\_\_ 15

# Reaction Prediction

In each of the following examples:

- State what type of reaction is expected.
- Tell whether the reaction will occur or not, and why.
- Write the balanced equation for those reactions that do take place; write the symbols and formulas of the reactants for those reactions that do occur.
- Indicate whether double replacement reactions are reversible or irreversible.

- aluminum plus hydrochloric acid
- calcium hydroxide plus nitric acid
- aluminum plus magnesium
- magnesium plus zinc nitrate
- mercury plus oxygen
- zinc chloride plus hydrogen sulfide
- dinitrogen pentoxide plus water
- silver chloride plus sodium nitrate
- sodium chlorate (heated)
- barium nitrate plus sodium chromate
- sodium bromide plus silver nitrate
- calcium phosphate plus aluminum sulfate
- zinc carbonate (heated)

(continued)

14. mercury (I) sulfate plus ammonium nitrate
15. potassium plus fluorine
16. potassium nitrate plus zinc phosphate
17. lithium oxide plus water
18. sodium chloride (electrolyzed)
19. silver plus barium
20. iron (III) hydroxide plus phosphoric acid
21. sodium plus nitric acid
22. iron (III) iodide plus cupric nitrate
23. copper plus sulfuric acid
24. lead plus potassium chlorate
25. sulfur dioxide plus water
26. oxygen plus sulfur
27. sodium sulfate plus barium chloride
28. ammonium phosphate plus lithium hydroxide
29. hydrogen plus oxygen
30. mercury plus nitric acid



31. sodium oxide plus water
32. calcium carbonate plus lithium chloride
33. mercury (I) sulfate plus hydrochloric acid
34. potassium nitrate (heated)
35. chlorine plus bromine
36. mercury (I) nitrate plus sodium carbonate
37. magnesium plus hydrochloric acid
38. water (electrolyzed)
39. ammonium nitrite plus barium hydroxide
40. ammonium sulfate plus calcium hydroxide
41. mercury (II) oxide (heated)
42. ammonium phosphate plus aluminum chloride
43. barium oxide plus water
44. iron (III) hydroxide plus nitric acid
45. calcium plus oxygen
46. calcium plus phosphoric acid

(continued)

47. calcium chloride plus ammonium hydroxide
48. aluminum sulfide plus hydrochloric acid
49. magnesium plus sulfur
50. calcium plus aluminum chloride
51. potassium hydroxide plus hydrosulfuric acid
52. sodium carbonate plus sulfuric acid
53. barium sulfate plus calcium chloride
54. silver plus mercurous nitrate
55. barium carbonate (heated)
56. lithium plus bromine
57. sodium chloride plus potassium chromate
58. potassium sulfide plus iron (II) nitrate
59. iodine plus ammonium fluoride
60. sodium plus calcium
61. aluminum chloride (electrolyzed)
62. lead chlorate plus sodium sulfide
63. sulfur trioxide plus water

(continued)

64. calcium carbonate plus hydrochloric acid
65. iron plus sodium bromide
66. ammonium acetate plus iron (II) chloride
67. silver bromide plus ammonium sulfate
68. zinc plus sulfuric acid
69. neon plus potassium
70. iron plus potassium iodide
71. lead (II) hydroxide plus hydrochloric acid
72. iron plus sulfur
73. potassium chlorate (heated)
74. oxygen plus chlorine
75. silver iodide plus iron (III) sulfide
76. ferrous carbonate plus phosphoric acid
77. potassium iodide plus ammonium nitrate
78. potassium plus sodium nitrate (fused)
79. bromine plus sodium chloride
80. silver sulfide plus hydrochloric acid

(continued)

81. magnesium nitrate plus hydrochloric acid
82. ammonia plus hydrogen chloride
83. zinc hydroxide plus sulfuric acid
84. calcium oxide plus water
85. sodium plus chlorine
86. calcium hydroxide (heated)
87. fluorine plus potassium bromide
88. ammonium hydroxide plus sulfuric acid
89. sodium chloride plus potassium nitrate
90. lead plus tin (II) nitrate
91. carbon dioxide plus water
92. chlorine plus lithium bromide
93. lithium hydroxide plus phosphoric acid
94. potassium sulfite plus nitric acid
95. ammonium chloride plus potassium hydroxide
96. strontium carbonate plus nitric acid
97. tin plus mercury (I) nitrate



98. ammonium sulfite plus hydrochloric acid
99. magnesium carbonate plus phosphoric acid
100. aluminum sulfite plus hydrochloric acid