

Chapter 11:Chemical Reactions

Section 11.1:Describing Chemical Reactions

Section 11.2:Types of Chemical Reactions

Section 11.3:Reactions in an Aqueous Solution

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VOCABULARY

- activity series
- balanced equation
- catalyst
- chemical equation
- coefficients
- combustion reaction
- combination reaction
- complete ionic equation
- decomposition reaction
- double displacement reaction
- net ionic equation
- single replacement reaction
- skeleton equation
- spectator ion

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## Section 11.1:Describing Chemical Reactions

Word Equations

Iron reacts with oxygen to produce iron (III) oxide

reactants  $\longrightarrow$  productsiron + oxygen  $\longrightarrow$  iron (III) oxide

Write the **names** of the reactants to the left of an arrow separated by plus signs, write the names of the products to the right of an arrow separated by plus signs.

Chemical Equations

$$\text{Fe (s)} + \text{O}_2 \text{ (g)} \longrightarrow \text{Fe}_2\text{O}_3 \text{ (s)}$$
'skeleton equation'

Write the **formula** of the reactants to the left of the yields sign (arrow) and the formula of the products to the right.

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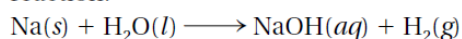
**Table 11.1** p. 323**Symbols Used in Chemical Equations**

Symbol	Explanation
+	Used to separate two reactants or two products
$\longrightarrow$	"Yields," separates reactants from products
$\rightleftharpoons$	Used in place of $\longrightarrow$ for reversible reactions
(s)	Designates a reactant or product in the solid state; placed after the formula
(l)	Designates a reactant or product in the liquid state; placed after the formula
(g)	Designates a reactant or product in the gaseous state; placed after the formula
(aq)	Designates an aqueous solution; the substance is dissolved in water; placed after the formula
$\xrightarrow{\Delta}$ $\xrightarrow{\text{heat}}$	Indicates that heat is supplied to the reaction
$\xrightarrow{\text{Pt}}$	A formula written above or below the yield sign indicates its use as a catalyst (in this example, platinum).

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**Practice Problems**

1. Write a sentence that describes this chemical reaction.



2. Sulfur burns in oxygen to form sulfur dioxide. Write a skeleton equation for this chemical reaction. Include appropriate symbols from Table 11.1.

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**Practice Problems**

3. Balance each equation.
- $\text{AgNO}_3 + \text{H}_2\text{S} \longrightarrow \text{Ag}_2\text{S} + \text{HNO}_3$
  - $\text{Zn}(\text{OH})_2 + \text{H}_3\text{PO}_4 \longrightarrow \text{Zn}_3(\text{PO}_4)_2 + \text{H}_2\text{O}$
4. Rewrite these word equations as balanced chemical equations.
- hydrogen + sulfur  $\longrightarrow$  hydrogen sulfide
  - iron(III) chloride + calcium hydroxide  $\longrightarrow$  iron(III) hydroxide + calcium chloride

5. Balance each equation.
- $\text{FeCl}_3 + \text{NaOH} \longrightarrow \text{Fe}(\text{OH})_3 + \text{NaCl}$
  - $\text{CS}_2 + \text{Cl}_2 \longrightarrow \text{CCl}_4 + \text{S}_2\text{Cl}_2$
6. Write and balance this equation.  
calcium hydroxide + sulfuric acid  $\longrightarrow$   
calcium sulfate + water

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**Section 11.2: Types of Chemical Reactions**

- most reactions can be classified into 5 basic types
  - Synthesis (also called Combination)
  - Decomposition
  - Single Displacement
  - Double Displacement
  - Combustion

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## Synthesis

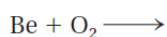
- synthesis comes from Greek 'sunthesis' meaning to put in together
- a chemical change in which two or more substances react to form a single new substance

EXAMPLE:



### Practice Problems

13. Complete and balance this equation for a combination reaction.



14. Write and balance the equation for the formation of magnesium nitride ( $\text{Mg}_3\text{N}_2$ ) from its elements.

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## Decomposition

- a single compound breaks down into two or more simpler substances
- difficult sometimes to predict the products unless the reactant is a binary compound

EXAMPLE:



### Practice Problems

15. Complete and balance this decomposition reaction.



16. Write the formula for the binary compound that decomposes to the products  $\text{H}_2$  and  $\text{Br}_2$ .

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Single Displacement Reactions

- a reaction in which a single element replaces a second element in a compound.

EXAMPLE:



Table 11.2

Activity Series of Metals

	Name	Symbol
Decreasing reactivity ↓	Lithium	Li
	Potassium	K
	Calcium	Ca
	Sodium	Na
	Magnesium	Mg
	Aluminum	Al
	Zinc	Zn
	Iron	Fe
	Lead	Pb
	(Hydrogen)	(H)*
	Copper	Cu
Mercury	Hg	
Silver	Ag	

\*Metals from Li to Na will replace H from acids and water; from Mg to Pb they will replace H from acids only.

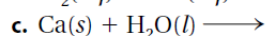
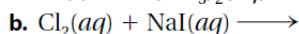
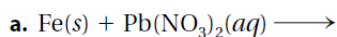
- determining if one metal will replace another is done using the Activity Series Table at left.
- a metal will replace any metal listed *below* it in the series
- Therefore, iron will displace copper in copper containing compounds, but will not replace calcium or magnesium

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- halogens can replace other halogens as well.
- the reactivity decreases as you go DOWN Group 7A
- therefore, Bromine will replace iodine but NOT chlorine in the two reactions below

**Practice Problem**

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



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Double Displacement Reactions

- as the name implies, this reaction involves portions of both compounds swapping places

For a reaction of this type to occur, one of the following MUST be true:

- 1) One of the products is only slightly soluble and precipitates from the solution.



CdS is a yellow solid

- 2) One of the products is a gas.



HCN is hydrogen cyanide gas

- 3) One of the products is a molecular compound such as water.

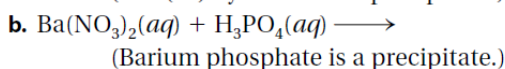
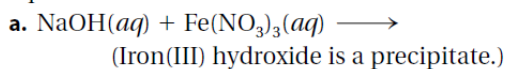


neutralization of an base by the addition of an acid

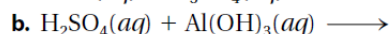
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**Practice Problems**

18. Write the products of these double-replacement reactions. Then balance each equation.



19. Write a balanced equation for each reaction.



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Combustion

- combustion reactions always involve oxygen as one of the reactants and typically release large amounts of energy in the form of heat or light or both
- combustion reactions of hydrocarbons (contain both H and C) invariably produce carbon dioxide and water as products

EXAMPLE:

**Practice Problems**

20. Write a balanced equation for the complete combustion of each compound.
  - a. formic acid ( $\text{HCOOH}$ )
  - b. heptane ( $\text{C}_7\text{H}_{16}$ )
21. Write a balanced equation for the complete combustion of glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ).

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## Section 11.3: Reactions in an Aqueous Solution

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