

GLOBAL  
EDITION



# Basic Chemistry

FIFTH EDITION

Timberlake • Timberlake

 **Pearson**

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## ENGAGE

Why is sodium phosphate an ionic compound and diphosphorus pentoxide a molecular compound?

- b.  $\text{NiSO}_4$ , consisting of a cation of a transition element and a polyatomic ion  $\text{SO}_4^{2-}$ , is an ionic compound. As a transition element, Ni forms more than one type of ion. In this formula, the 2− charge of  $\text{SO}_4^{2-}$  is balanced by one nickel ion,  $\text{Ni}^{2+}$ . In the name, a Roman numeral written after the metal name, nickel(II), specifies the 2+ charge. The anion  $\text{SO}_4^{2-}$  is a polyatomic ion named sulfate. The compound is named nickel(II) sulfate.
- c.  $\text{SO}_3$  consists of two nonmetals, which indicates that it is a molecular compound. The first element S is sulfur (no prefix is needed). The second element O, oxide, has subscript 3, which requires a prefix *tri* in the name. The compound is named sulfur trioxide.

## STUDY CHECK 6.11

What is the name of  $\text{Fe}(\text{NO}_3)_3$ ?

## ANSWER

iron(III) nitrate

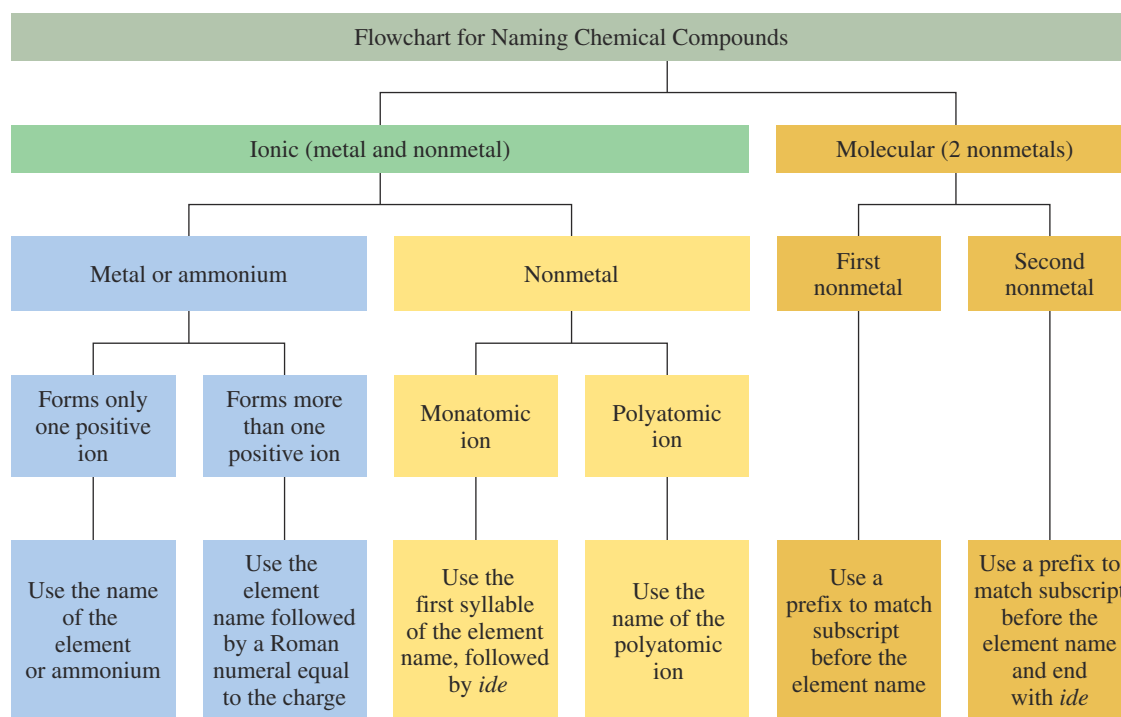


FIGURE 6.4 ► A flowchart illustrates naming for ionic and molecular compounds.

🔍 Why are the names of some metal ions followed by a Roman numeral in the name of a compound?

## QUESTIONS AND PROBLEMS

## 6.5 Molecular Compounds: Sharing Electrons

**LEARNING GOAL** Given the formula of a molecular compound, write its correct name; given the name of a molecular compound, write its formula.

**6.47** Name each of the following molecular compounds:

- a.  $\text{PBr}_3$       b.  $\text{Cl}_2\text{O}$       c.  $\text{CBr}_4$   
d.  $\text{HF}$       e.  $\text{NF}_3$

**6.48** Name each of the following molecular compounds:

- a.  $\text{CS}_2$       b.  $\text{P}_2\text{O}_5$       c.  $\text{SiO}_2$   
d.  $\text{PCl}_3$       e.  $\text{CO}$

**6.49** Name each of the following molecular compounds:

- a.  $\text{N}_2\text{O}_3$       b.  $\text{Si}_2\text{Br}_6$       c.  $\text{P}_4\text{S}_3$   
d.  $\text{PCl}_5$       e.  $\text{SeF}_6$

**6.50** Name each of the following molecular compounds:

- a.  $\text{SiF}_4$       b.  $\text{IBr}_3$       c.  $\text{CO}_2$   
d.  $\text{N}_2\text{F}_2$       e.  $\text{N}_2\text{S}_3$

**6.51** Write the formula for each of the following molecular compounds:

- a. carbon tetrachloride      b. carbon monoxide  
c. phosphorus trichloride      d. dinitrogen tetroxide

- 6.52** Write the formula for each of the following molecular compounds:
- sulfur dioxide
  - silicon tetrachloride
  - iodine trifluoride
  - dinitrogen oxide
- 6.53** Write the formula for each of the following molecular compounds:
- oxygen difluoride
  - boron trichloride
  - dinitrogen trioxide
  - sulfur hexafluoride
- 6.54** Write the formula for each of the following molecular compounds:
- sulfur dibromide
  - carbon disulfide
  - tetraphosphorus hexoxide
  - dinitrogen pentoxide

### Applications

- 6.55** Name each of the following ionic or molecular compounds:
- $\text{Al}_2(\text{SO}_4)_3$ , antiperspirant
  - $\text{CaCO}_3$ , antacid
  - $\text{N}_2\text{O}$ , “laughing gas,” inhaled anesthetic
  - $\text{Mg}(\text{OH})_2$ , laxative
- 6.56** Name each of the following ionic or molecular compounds:
- $\text{Al}(\text{OH})_3$ , antacid
  - $\text{FeSO}_4$ , iron supplement in vitamins
  - $\text{NO}$ , vasodilator
  - $\text{Cu}(\text{OH})_2$ , fungicide

## Follow Up

### COMPOUNDS AT THE PHARMACY



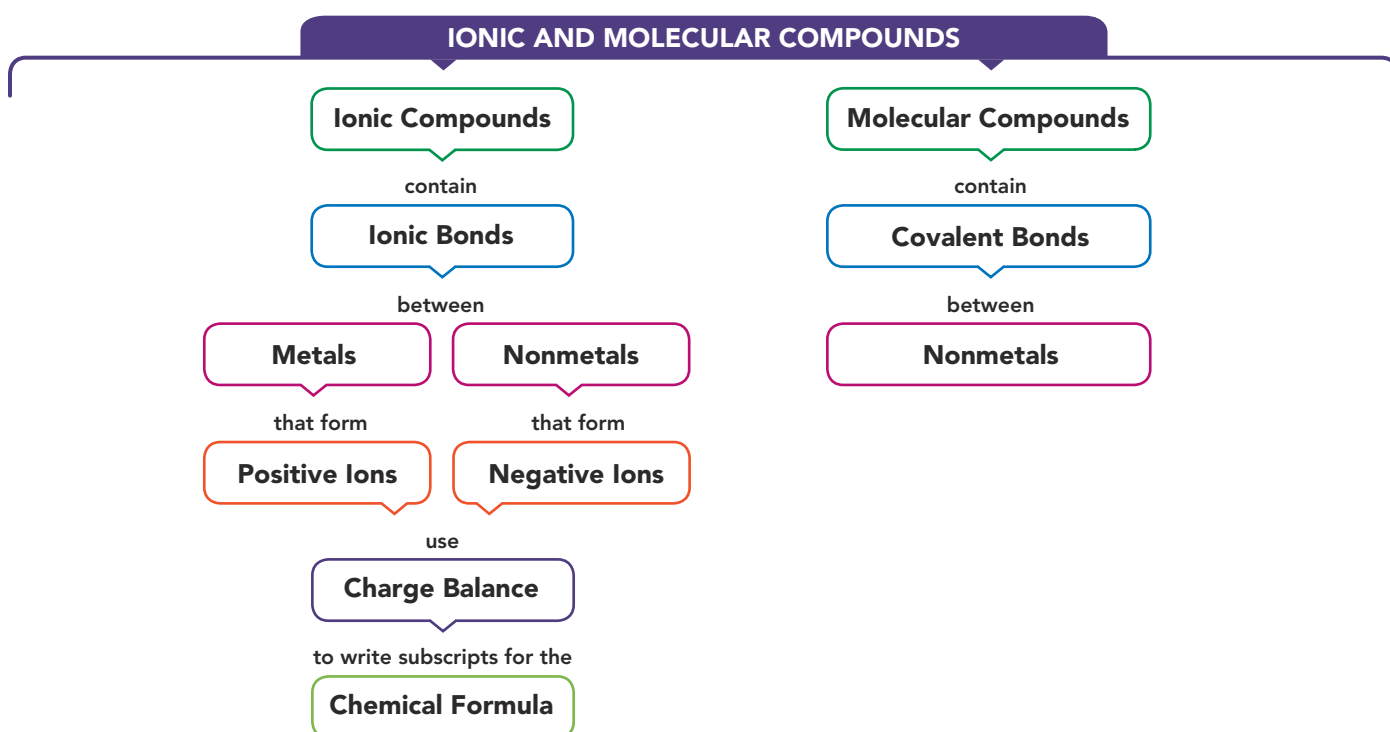
A few days ago, Richard went back to the pharmacy to pick up aspirin,  $\text{C}_9\text{H}_8\text{O}_4$ , and acetaminophen,  $\text{C}_8\text{H}_9\text{NO}_2$ . He also wanted to talk to Sarah about a way to treat his sore toe. Sarah recommended soaking his foot in a solution of Epsom salts, which is magnesium sulfate. Richard also asked

Sarah to recommend an antacid for his upset stomach and an iron supplement. Sarah suggested an antacid that contains calcium carbonate and aluminum hydroxide, and iron(II) sulfate as an iron supplement. Richard also picked up toothpaste containing tin(II) fluoride, and carbonated water, which contains carbon dioxide.

### Applications

- 6.57** Write the chemical formula for each of the following:
- magnesium sulfate
  - tin(II) fluoride
  - aluminum hydroxide
- 6.58** Write the chemical formula for each of the following:
- calcium carbonate
  - carbon dioxide
  - iron(II) sulfate
- 6.59** Identify each of the compounds in problem 6.57 as ionic or molecular.
- 6.60** Identify each of the compounds in problem 6.58 as ionic or molecular.

## CONCEPT MAP



**polyatomic ion** A group of covalently bonded nonmetal atoms that has an overall electrical charge.



## CORE CHEMISTRY SKILLS

The chapter section containing each Core Chemistry Skill is shown in parentheses at the end of each heading.

### Writing Positive and Negative Ions (6.1)

- In the formation of an ionic bond, atoms of a metal lose and atoms of a nonmetal gain valence electrons to acquire a stable electron configuration, usually eight valence electrons.
- This tendency of atoms to attain a stable electron configuration is known as the octet rule.

**Example:** State the number of electrons lost or gained by atoms and the ion formed for each of the following to obtain a stable electron configuration:

- a. Br                      b. Ca                      c. S

**Answer:** a. Br atoms gain one electron to achieve a stable electron configuration,  $\text{Br}^-$ .  
 b. Ca atoms lose two electrons to achieve a stable electron configuration,  $\text{Ca}^{2+}$ .  
 c. S atoms gain two electrons to achieve a stable electron configuration,  $\text{S}^{2-}$ .

### Writing Ionic Formulas (6.2)

- The chemical formula of a compound represents the lowest whole-number ratio of the atoms or ions.
- In the chemical formula of an ionic compound, the sum of the positive and negative charges is always zero.
- Thus, in a chemical formula of an ionic compound, the total positive charge is equal to the total negative charge.

**Example:** Write the formula for magnesium phosphide.

**Answer:** Magnesium phosphide is an ionic compound that contains the ions  $\text{Mg}^{2+}$  and  $\text{P}^{3-}$ .

Using charge balance, we determine the number(s) of each type of ion.

$$3(2+) + 2(3-) = 0$$

$3\text{Mg}^{2+}$  and  $2\text{P}^{3-}$  give the formula  $\text{Mg}_3\text{P}_2$ .

### Naming Ionic Compounds (6.3)

- In the name of an ionic compound made up of two elements, the name of the metal ion, which is written first, is the same as its element name.
- For metals that form two or more ions, a Roman numeral that is equal to the ionic charge is placed in parentheses immediately after the name of the metal.
- The name of a nonmetal ion is obtained by using the first syllable of its element name followed by *ide*.

**Example:** What is the name of  $\text{PbS}$ ?

**Answer:** This compound contains the  $\text{S}^{2-}$  ion which has a 2- charge.

For charge balance, the positive ion must have a charge of 2+.

$$\text{Pb?} + (2-) = 0; \text{Pb} = 2+$$

Because lead can form two different positive ions, a Roman numeral (II) is used in the name of the compound: lead(II) sulfide.

### Writing the Names and Formulas for Molecular Compounds (6.5)

- When naming a molecular compound, the first nonmetal in the formula is named by its element name; the second nonmetal is named using the first syllable of its element name followed by *ide*.
- When a subscript indicates two or more atoms of an element, a prefix is shown in front of its name.

**Example:** Name the molecular compound  $\text{BrF}_5$ .

**Answer:** Two nonmetals share electrons and form a molecular compound. Br (first nonmetal) is bromine; F (second nonmetal) is fluoride. In the name for a molecular compound, prefixes indicate the subscripts in the formulas. The subscript 1 is understood for Br. The subscript 5 for fluoride is written with the prefix *penta*. The name is bromine pentafluoride.

## UNDERSTANDING THE CONCEPTS

The chapter sections to review are shown in parentheses at the end of each question.

- 6.61** a. Why does calcium form a  $\text{Ca}^{2+}$  ion instead of a  $\text{Ca}^+$  ion? (6.1)  
 b. What is the electronic configuration of  $\text{Ca}^{2+}$ ?  
 c. Which element has the same electronic configuration as  $\text{Ca}^{2+}$ ?
- 6.62** a. Why does fluorine form an  $\text{F}^-$  ion instead of an  $\text{F}^+$  ion? (6.1)  
 b. What is the electronic configuration of  $\text{F}^-$ ?  
 c. Which element has the same electronic configuration as  $\text{F}^-$ ?

**6.63** Identify each of the following atoms or ions: (6.1)

$\begin{array}{c} 18 e^- \\ 15 p^+ \\ 16 n \end{array}$ <b>A</b>	$\begin{array}{c} 8 e^- \\ 8 p^+ \\ 8 n \end{array}$ <b>B</b>	$\begin{array}{c} 28 e^- \\ 30 p^+ \\ 35 n \end{array}$ <b>C</b>	$\begin{array}{c} 23 e^- \\ 26 p^+ \\ 28 n \end{array}$ <b>D</b>
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**6.64** Identify each of the following atoms or ions: (6.1)

$\begin{array}{c} 2 e^- \\ 3 p^+ \\ 4 n \end{array}$ <b>A</b>	$\begin{array}{c} 0 e^- \\ 1 p^+ \\ 1 n \end{array}$ <b>B</b>	$\begin{array}{c} 3 e^- \\ 3 p^+ \\ 4 n \end{array}$ <b>C</b>	$\begin{array}{c} 10 e^- \\ 7 p^+ \\ 8 n \end{array}$ <b>D</b>
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- 6.65** Consider the following Lewis symbols for elements X and Y: (6.1, 6.2, 6.5)



- What are the group numbers of X and Y?
  - Will a compound of X and Y be ionic or molecular?
  - What ions would be formed by X and Y?
  - What would be the formula of a compound of X and Y?
  - What would be the formula of a compound of X and sulfur?
  - What would be the formula of a compound of Y and chlorine?
  - Is the compound in part **f** ionic or molecular?
- 6.66** Consider the following Lewis symbols for elements X and Y: (6.1, 6.2, 6.5)



- What are the group numbers of X and Y?
- Will a compound of X and Y be ionic or molecular?
- What ions would be formed by X and Y?
- What would be the formula of a compound of X and Y?
- What would be the formula of a compound of X and sulfur?
- What would be the formula of a compound of Y and chlorine?
- Is the compound in part **f** ionic or molecular?

- 6.67** Using each of the following electron configurations, give the formulas of the cation and anion that form, the formula for the compound they form, and its name. (6.2, 6.3)

Electron Configurations	Cation	Anion	Formula of Compound	Name of Compound
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$				
$1s^2 2s^1$				
$1s^2 2s^2 2p^2$				

- 6.68** Using each of the following electron configurations, give the formulas of the cation and anion that form, the formula for the compound they form, and its name. (6.2, 6.3)

Electron Configurations	Cation	Anion	Formula of Compound	Name of Compound
$1s^2 2s^2 2p^6 3s^2 3p^1$				
$1s^2 2s^2 2p^6 3s^2 3p^4 s^1$				
$1s^2 2s^2$				

## ADDITIONAL QUESTIONS AND PROBLEMS

- 6.69** Write the name for the following: (6.1)  
**a.**  $\text{N}^{3-}$       **b.**  $\text{Mg}^{2+}$       **c.**  $\text{O}^{2-}$       **d.**  $\text{Al}^{3+}$
- 6.70** Write the name for the following: (6.1)  
**a.**  $\text{K}^+$       **b.**  $\text{Na}^+$       **c.**  $\text{Ba}^{2+}$       **d.**  $\text{Cl}^-$
- 6.71** Consider an ion with the symbol  $\text{X}^{3+}$  and the electronic configuration  $1s^2 2s^2 2p^6$ . (6.1, 6.2, 6.3)  
**a.** What is the group number of the element X?  
**b.** What is the element X?  
**c.** What is the Lewis symbol of this element?  
**d.** What is the formula of the compound formed from X and phosphate?
- 6.72** Consider an ion with the symbol  $\text{Z}^-$  and the electronic configuration  $1s^2 2s^2 2p^6 3s^2 3p^6$ . (6.1, 6.2, 6.3)  
**a.** What is the group number of the element Z?  
**b.** What is the element Z?  
**c.** What is the Lewis symbol of this element?  
**d.** What is the formula of the compound formed from a nickel(II) ion and Z?
- 6.73** Rust consists of iron(III) oxide and some iron(III) hydroxide. (6.1, 6.2, 6.3, 6.4)  
**a.** What is the symbol of iron(III) ion?  
**b.** How many protons and electrons are there in this ion?  
**c.** What is the formula of iron(III) oxide?  
**d.** What is the formula of iron(III) hydroxide?
- 6.74** Some ionic compounds such as strontium carbonate and barium chlorate are used as colorant in fireworks. (6.1, 6.2, 6.3, 6.4)  
**a.** What are the symbols of strontium and barium ions?  
**b.** How many protons and electrons are there in a strontium ion?  
**c.** What is the formula of strontium carbonate?  
**d.** What is the formula of barium chlorate?
- 6.75** Write the formula for each of the following ionic compounds: (6.2, 6.3)  
**a.** silver bromide      **b.** calcium fluoride  
**c.** aluminum sulfide      **d.** calcium phosphate  
**e.** iron (II) chloride      **f.** magnesium nitride
- 6.76** Write the formula for each of the following ionic compounds: (6.2, 6.3)  
**a.** nickel(III) oxide      **b.** iron(III) sulfide  
**c.** lead(II) sulfate      **d.** chromium(III) iodide  
**e.** lithium nitride      **f.** gold(I) oxide
- 6.77** Name each of the following molecular compounds: (6.5)  
**a.**  $\text{SF}_4$       **b.**  $\text{PH}_3$       **c.**  $\text{BBr}_3$   
**d.**  $\text{PF}_5$       **e.**  $\text{Cl}_2\text{O}_7$       **f.**  $\text{P}_2\text{O}_5$
- 6.78** Name each of the following molecular compounds: (6.5)  
**a.**  $\text{B}_2\text{H}_6$       **b.**  $\text{ClF}_3$       **c.**  $\text{NO}_2$   
**d.**  $\text{CCl}_4$       **e.**  $\text{PCl}_3$       **f.**  $\text{N}_2\text{O}_5$