Writing Chemical Formulas and Naming Chemical Compounds

3.4

Section Preview/ Specific Expectations

In this section, you will

- **write** the formulas of binary and tertiary compounds, including compounds that contain elements with multiple valences
- **communicate** formulas using IUPAC and traditional systems
- **recognize** the formulas of compounds in various contexts
- **communicate** your understanding of the following terms: *chemical formula, valence, polyatomic ions, zero sum rule, chemical nomenclature, binary compound, Stock system, tertiary compounds*

You have used Lewis structures to demonstrate how ionic and covalent bonds form between atoms. When given two elements, you determined how many atoms of each element bond together to form a compound, according to the octet rule. For example, you used the periodic table and your understanding of the octet rule to determine how calcium and bromine bond to form an ionic compound. Using a Lewis structure, you determined that calcium and bromine form a compound that contains two bromine atoms for every calcium atom, as shown in Figure 3.39.

Chemical Formulas

Lewis structures are helpful for keeping track of electron transfers in bonding and for making sure that the octet rule is obeyed. As well, Lewis structures can be used to help determine the ratio of the atoms in a compound. To communicate this ratio, chemists use a special kind of shorthand called a **chemical formula**. A chemical formula provides two important pieces of information:

1. the elements that make up the compound
2. the number of atoms of each element that are present in a compound

The order in which the elements are written also communicates important information. The less electronegative element or ion is usually listed first in the formula, and the more electronegative element or ion comes second. For example, the ionic compound that is formed from calcium and bromine is written $CaBr_2$. Calcium, a metal with low electronegativity, is written first. The subscript 2 after the bromine indicates that there are two bromine atoms for every calcium atom.

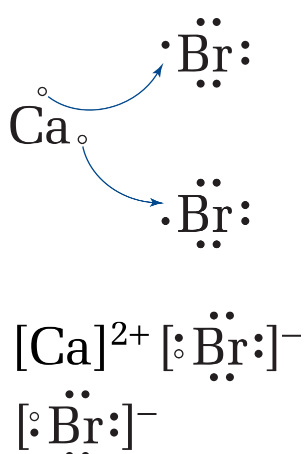

Figure 3.39 These Lewis structures show the formation of calcium bromide.

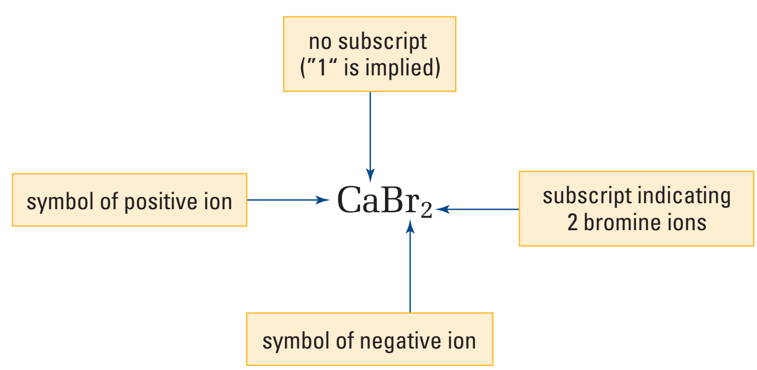

Figure 3.40 $CaBr_2$ **is the chemical formula of the compound formed by calcium and bromine. When a subscript is omitted, only one atom is present per formula unit.**

What a Chemical Formula Represents

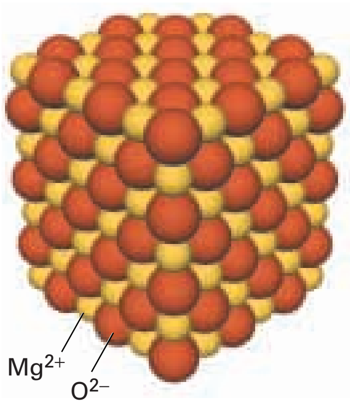

Figure 3.41 **In a crystal of magnesium oxide, MgO, magnesium and oxygen atoms exist in a 1:1 ratio.**

For covalent compounds, the chemical formula represents how many of each type of atom are in each molecule. For example, the formula NH_3 signifies that a molecule of ammonia contains one nitrogen atom and three hydrogen atoms. The formula C_2H_6 tells you that a molecule of propane contains two atoms of carbon and six atoms of hydrogen.

For ionic compounds, the formula represents *a ratio rather than a discrete particle*. For example, the formula for magnesium oxide, MgO, signifies that magnesium and oxygen exist in a one-to-one atomic ratio. Recall that MgO exists in a lattice structure held together by ionic bonds, as shown in Figure 3.41. The formula MgO represents the ratio in which ions are present in the compound.

CHECKPOINT

What does the formula of calcium bromide represent?

Using Valence Numbers to Describe Bonding Capacity

You have seen how Lewis structures can help you draw models of ionic, covalent, and polar covalent compounds. When you draw a Lewis structure, you can count how many electrons are needed by each atom to achieve a stable octet. Thus, you can find out the ratio in which the atoms combine. Once you know the ratio of the atoms, you can write the chemical formula of the compound. Drawing Lewis structures can become overwhelming, however, when you are dealing with large molecules. Is there a faster and easier method for writing chemical formulas?

Every element has a certain capacity to combine with other atoms. An atom of a Group 1 (IA) element, for example, has the capacity to lose one electron from its valence level in order to bond with another atom. A number is assigned to each element to describe the element's bonding capacity. This number is called the **valence**. Thus, Group 1 (IA) elements, such as sodium and lithium, have a valence of +1. The 1 indicates that these elements tend to have one electron involved in bonding. This makes sense, because Group 1 elements have only one electron in their outer electron energy level. The + indicates that these elements tend to give up their electrons, becoming positively charged ions. They may transfer their electrons, or they may attract the electron relatively weakly in a polar covalent bond.

On the other hand, Group 17 (VIIA) elements (the halogens) have a valence of –1. Again, the 1 indicates that these elements tend to have one electron involved in bonding. However, they need to *gain* an electron to achieve a stable octet. In general, halogens become more negatively charged when they participate in bonding.

As a general rule, if two atoms form an ionic bond, the valence tells you the charges on the ions that are formed. If a covalent bond is formed, the valence tells you how many electrons the atoms contribute to the covalent bond.

You can use the periodic table to predict valence numbers. For example, Group 2 (IIA) elements have two electrons in their outer energy level. To achieve a stable octet, they need to lose these two electrons. Therefore, the valence for all Group 2 elements is +2.

Practice Problems

14. Use the periodic table to predict the most common valences of the atoms in Groups 16 (VIA) and 17 (VIIA).

15. If you had to assign a valence to the noble gases, what would it be? Explain your answer.

The smaller atoms of elements in the first two periods usually have only one common valence, which is easily determined from the periodic table. Many larger elements, however, have more than one valence because the electron distribution in these elements is much more complex. Therefore, you will have to memorize the valences of the elements that are commonly used in this course. Some useful valences are listed in Table 3.3, with the most common valences listed first.

Table 3.3 Common Valences of Selected Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
H(+1)																
Li(+1)	Be(+2)													N(−3)	O(−2)	F(−1)
Na(+1)	Mg(+2)													P(−3)	S(−2)	Cl(−1)
K(+1)	Ca(+2)				Cr(+3) Cr(+2) Cr(+6)		Fe(+3) Fe(+2)	Co(+2) Co(+3)	Ni(+2) Ni(+3)	Cu(+2) Cu(+1)	Zn(+2)	Ga(+3)				Br(−1)
Rb(+1)	Sr(+2)									Ag(+1)	Cd(+2)		Sn(+4) Sn(+2)			I(−1)
Cs(+1)	Ba(+2)									Au(+3) Au(+1)	Hg(+2) Hg(+1)		Pb(+2) Pb(+4)			

Polyatomic Ions

Some compounds contain ions that are made from more than one atom. These ions are called **polyatomic ions**. (The prefix *poly* means "many.") Calcium carbonate, $CaCO_3$, which is found in chalk, contains one calcium cation and one polyatomic anion called carbonate, CO_3^{2-}.

Polyatomic ions are in fact *charged molecules*. For example, the carbonate ion consists of one carbon atom covalently bonded to three oxygen atoms. The entire molecule has a charge of −2. Therefore, its valence is −2, as well. Polyatomic ions remain unchanged in simple chemical reactions because of the strong bonds that hold the component atoms together. They behave as a single unit and should be treated as a single ion.

Table 3.4 on the next page gives the valences, formulas, and names of many common polyatomic ions.

Language LINK

It is important to learn the names and valences of the five most common polyatomic ions: nitrate, carbonate, chlorate, sulfate, and phosphate. These ions form many of the chemicals in nature and in common use. While the task seems overwhelming, it may help to learn the "big five" using a mnemonic, or memory aid. You can use the following mnemonic to remember their names, valences, and number of oxygen atoms:

NICK the CAMEL had a CLAM for SUPPER in PHOENIX.

The first letter identifies the polyatomic ion. The number of vowels represents the valence. The number of consonants represents the number of oxygen atoms. For example, NICK (nitrate) has three consonants and one vowel. Therefore, nitrate contains three oxygen atoms and has a valence of –1. (All of these valences are negative.)

Try to come up with your own mnemonic.

The most common polyatomic cation is the ammonium ion, $[NH_4^+]$. The five atoms in NH_4^+ form a particle with a +1 charge. Because the atoms are bonded together strongly, the polyatomic ion is not altered in most chemical reactions. For example, when ammonium chloride is dissolved in water, the only ions in the solution are ammonium ions and chloride ions.

Table 3.4 Names and Valences of Some Common Ions

Valence = –1			
Ion	**Name**	**Ion**	**Name**
CN^-	cyanide	$H_2PO_3^-$	dihydrogen phosphite
CH_3COO^-	acetate	$H_2PO_4^-$	dihydrogen phosphate
ClO^-	hypochlorite	MnO_4^-	permanganate
ClO_2^-	chlorite	NO_2^-	nitrite
ClO_3^-	chlorate	NO_3^-	nitrate
ClO_4^-	perchlorate	OCN^-	cyanate
HCO_3^-	hydrogen carbonate	HS^-	hydrogen sulfide
HSO_3^-	hydrogen sulfite	OH^-	hydroxide
HSO_4^-	hydrogen sulfate	SCN^-	thiocyanate

Valence = –2			
Ion	**Name**	**Ion**	**Name**
CO_3^{2-}	carbonate	O_2^{2-}	peroxide
$C_2O_4^{2-}$	oxalate	SiO_3^{2-}	silicate
CrO_4^{2-}	chromate	SO_3^{2-}	sulfite
$Cr_2O_7^{2-}$	dichromate	SO_4^{2-}	sulfate
HPO_3^{2-}	hydrogen phosphite	$S_2O_3^{2-}$	thiosulfate
HPO_4^{2-}	hydrogen phosphate		

Valence = –3			
Ion	**Name**	**Ion**	**Name**
AsO_3^{3-}	arsenite	PO_3^{3-}	phosphite
AsO_4^{3-}	arsenate	PO_4^{3-}	phosphate

Writing Chemical Formulas Using Valences

You can use valences to write chemical formulas. This method is faster than using Lewis structures to determine chemical formulas. As well, you can use this method for both ionic and covalent compounds. In order to write a chemical formula using valences, you need to know which elements (or polyatomic ions) are in the compound, and their valences. You also need to know how to use the **zero sum rule**: *For neutral chemical formulas containing ions, the sum of positive valences plus negative valences of the atoms in a compound must equal zero.*

In the compound potassium fluoride, KF, each potassium ion has a charge of +1. Each fluoride ion has a charge of –1. Because there is one of each ion in the formula, the sum of the valences is zero.

What is the formula of a compound that consists of magnesium and chlorine? You know that the valence of magnesium, Mg, is +2. The valence of chlorine, Cl, is −1. The formula MgCl is not balanced, however, because it does not yet obey the zero sum rule. How can you balance this formula? You might be able to see, at a glance, that two chlorine atoms are needed for every magnesium atom. If it is not obvious how to balance a formula, you can follow these steps:

1. Write the unbalanced formula. Remember that the metal is first and the non-metal is second.

   Mg Cl

2. Place the valence of each element on top of the appropriate symbol.

   $\overset{+2}{\text{Mg}} \quad \overset{-1}{\text{Cl}}$

3. Using arrows, bring the numbers (without the signs) down to the subscript positions *by crossing over*.

   $\overset{+2}{\text{Mg}} \quad \overset{-1}{\text{Cl}}$

4. Check the subscripts. Any subscript of "1" can be removed.

   $MgCl_2$

You can check your formula by drawing a Lewis structure, as shown in Figure 3.42.

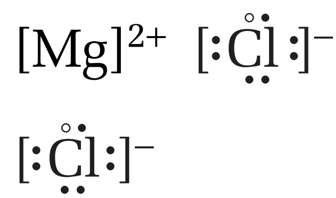

Figure 3.42 This Lewis structure represents magnesium chloride, $MgCl_2$. Each atom has achieved a stable octet.

Practice Problems

16. Write a balanced formula for a compound that contains sulfur and each of the following elements. Use a valence of −2 for sulfur.
    - **(a)** sodium
    - **(b)** calcium
    - **(c)** barium
    - **(d)** aluminum
    - **(e)** rubidium
    - **(f)** hydrogen
17. Write a balanced formula for a compound that contains calcium and each of the following elements.
    - **(a)** oxygen
    - **(b)** sulfur
    - **(c)** chlorine
    - **(d)** bromine
    - **(e)** phosphorus
    - **(f)** fluorine

PROBLEM TIP

After the crossing over step, you may need to reduce the subscripts to their lowest terms. For example, Mg_2O_2 becomes MgO. Be_2O_2 becomes BeO. Remember, formulas for ionic compounds represent ratios of ions.

How do you write and balance formulas that contain polyatomic ions? The same steps can be used, as long as you keep the atoms that belong to a polyatomic ion together. The easiest way to do this is to place brackets around the polyatomic ion at the beginning.

For example, suppose that you want to write a balanced formula for a compound that contains potassium and the phosphate ion. Use the following steps as a guide.

1. Write the unbalanced formula. Place brackets around any polyatomic ions that are present.

$$\begin{array}{ll} K & PO_4 \\ K & (PO_4) \end{array}$$

2. Write the valence of each ion above it. (Refer to Table 3.4.)

$$\begin{array}{ll} +1 & -3 \\ K & (PO_4) \end{array}$$

3. Cross over, and write the subscripts.

$$K_3(PO_4)_1$$

4. Tidy up the formula. Remember that you omit the subscript if there is only one particle in the ionic compound or molecule. Here the brackets are no longer needed, so they can be removed.

$$K_3PO_4$$

Pay close attention to the brackets when you are writing formulas that contain polyatomic ions. For example, how would you write the formula for a compound that contains ammonium and phosphate ions?

PROBLEM TIP

In this formula, the brackets must remain around the ammonium ion to distinguish the subscripts. The subscript 4 refers to how many hydrogen atoms are in each ammonium ion. The subscript 3 refers to how many ammonium ions are needed to form an ionic compound with the phosphate ion.

1. Write the unbalanced formula. Place brackets around any polyatomic ions that are present.

$$\begin{array}{ll} NH_4 & PO_4 \\ (NH_4) & (PO_4) \end{array}$$

2. Write the valence above each ion.

$$\begin{array}{ll} +1 & -3 \\ (NH_4) & (PO_4) \end{array}$$

3. Cross over, and write in the subscripts.

$$(NH_4)_3(PO_4)_1$$

4. Tidy up the formula. Remove the brackets only when the polyatomic ion has a subscript of “1”.

$$(NH_4)_3PO_4$$

Try the following problems to practise writing formulas for compounds containing polyatomic ions.

Practice Problems

18. Use the information in Table 3.4 to write a chemical formula for a compound that contains sodium and each of the following polyatomic ions.
 (a) nitrate (c) sulfite (e) thiosulfate
 (b) phosphate (d) acetate (f) carbonate

19. Repeat question 19 using magnesium instead of sodium.

Naming Chemical Compounds

When writing a chemical formula, you learned that you write the metal element first. Similarly, the metal comes first when naming a chemical compound. For example, sodium chloride is formed from the metal sodium and the non-metal chlorine. Think of other names you have seen in this chapter, such as beryllium chloride, calcium oxide, and aluminum oxide. In each case, the metal is first and the non-metal is second. In other words, the cation is first and the anion is second. This is just one of the rules in **chemical nomenclature**: the system that is used in chemistry for naming compounds.

A chemical formula identifies a specific chemical compound because it reveals the composition of the compound. Similarly, the name of a compound distinguishes the compound from all other compounds.

Figure 3.43 **Many common chemicals have trivial, or common, names.**

In the early days of chemistry, there were no rules for naming compounds. Often, compounds received the names of people or places. Some of the original names are still used today. They are called *trivial* or *common* names because they tell little or nothing about the chemistry of the compounds. For example, potassium nitrate, KNO_3, is commonly known as saltpetre. The Greek word for rock is petra, and saltpetre is a salt found crusted on rocks. The chemical name of a compound of ammonium and chloride ions, is ammonium chloride NH_4Cl. Long before NH_4Cl received this name, however, people commonly referred to it as sal ammoniac. They mined this ionic compound near the ancient Egyptian temple of Ammon in Libya. The name sal ammoniac literally means "salt of Ammon." Figure 3.43 shows other examples of common (trivial) names for familiar compounds.

Early chemists routinely gave trivial names to substances before understanding their chemical structure and behaviour. This situation changed during the mid- to late-1800s. By this time, chemistry was firmly established as a science. Chemists observed and discovered new patterns of chemical relationships (such as periodicity). As well, chemists discovered new chemical compounds with tremendous frequency. The rapidly increasing number of chemical compounds required a more organized method of nomenclature.

The International Union of Pure and Applied Chemistry (IUPAC) was formed in 1919 by a group of chemists. The main aim of IUPAC was to establish international standards for masses, measurement, names, and symbols used in the discipline of chemistry. To further that aim, IUPAC developed, and continues to develop, a consistent and thorough system of nomenclature for compounds.

Table 3.5 contains the IUPAC names of selected common compounds as well as their common names.

Table 3.5 Common Chemical Compounds

IUPAC name	Chemical formula	Common name	Use or propety
aluminum oxide	Al_2O_3	alumina	abrasive
calcium carbonate	$CaCO_3$	limestone, marble	building, sculpting
calcium oxide	CaO	lime	neutralizing acidified lakes
hydrochloric acid	HCl	muriatic acid	cleaning metal
magnesium hydroxide	$Mg(OH)_2$	milk of magnesia	antacid
dinitrogen monoxide	N_2O	laughing gas	used in dentistry as an anaesthetic
silicon dioxide	SiO_2	quartz sand	manufacturing glass
sodium carbonate	Na_2CO_3	washing soda	general cleaner
sodium chloride	$NaCl$	table salt	enhancing flavour
sodium hydrogen carbonate	$NaHCO_3$	baking soda	making baked goods rise
sodium hydroxide	$NaOH$	lye	neutralizing acids
sodium thiosulfate	NaS_2O_3	hypo	fixer in photography

Naming Binary Compounds Containing a Metal and a Non-metal

A **binary compound** is an inorganic compound that contains two elements. Binary compounds may contain a metal and a non-metal or two non-metals. Binary compounds are often ionic compounds. To name a binary ionic compound, name the cation first and the anion second. For example, the compound that contains sodium and chlorine is called sodium chloride.

In the subsections that follow, you will examine the rules for naming metals and non-metals in binary compounds.

Naming Metals in Chemical Compounds: The Stock System

The less electronegative element in a binary compound is always named first. Often this element is a metal. You use the same name as the element. For example, *sodium* chloride, NaCl, *calcium* oxide, CaO, and *zinc* sulfide, ZnS, contain the metals sodium, calcium, and zinc.

Many of the common metals are transition elements that have more than one possible valence. For example, tin is able to form the ions Sn^{2+} and Sn^{4+}, iron can form Fe^{2+} and Fe^{3+}, and copper can form Cu^{+} and Cu^{2+}. (The most common transition metals with more than one valence number are listed in Table 3.3.) The name of a compound must identify which ion is present in the compound. To do this, the element's name is used, followed by the valence in parentheses, written in Roman numerals. Therefore, Sn^{4+} is tin(IV), Fe^{3+} is iron(III), and Cu^{2+} is copper(II). This naming method is called the **Stock system** after Alfred Stock, a German chemist who first used it. Some examples of Stock system names are listed in Table 3.6.

Another Method for Naming Metals with Two Valences

In a method that predates the Stock system, two different endings are used to distinguish the valences of metals. The ending *-ic* is used to represent the *larger* valence number. The ending *-ous* is used to represent the *smaller* valence number. Thus, the ions Sn^{2+} and Sn^{4+} are named stann*ous* ion and stann*ic* ion. To use this system, you need to know the Latin name of an element. For example, the two ions of lead are the plumbous and plumbic ions. See Table 3.6 for more examples.

This naming method has several drawbacks. Many metals have more than two oxidation numbers. For example, chromium can form three different ions, and manganese can form five different ions. Another drawback is that the name does not tell you what the valence of the metal is. It only tells you that the valence is the smaller or larger of two.

Table 3.6 Two ways to Name Cations with Two Valences

element	ion	Stock system	Alternative system
copper	Cu^{+}	copper(I)	cuprous
	Cu^{2+}	copper(II)	cupric
mercury	$Hg_2{}^{2+}$	mercury(I)	mercurous
	Hg^{2+}	mercury(II)	mercuric
lead	Pb^{2+}	lead(II)	plumbous
	Pb^{4+}	lead(IV)	plumbic

mind STRETCH

Some types of ionic compounds can absorb water so that each formula unit is attached to a specific number of water molecules. They are called *hydrates*. $BaOH_2 \bullet 8H_2O$ is called barium hydroxide octahydrate. $CaSO_4 \bullet 2H_2O$ is called calcium sulfate dihydrate. Can you see the pattern? Try naming $MgSO_4 \bullet 7H_2O$. Use Table 3.8 to help you. You will learn more about hydrates in Chapter 6.

Naming Non-Metals in Chemical Compounds

To distinguish the non-metal from the metal in the name of a chemical compound, the non-metal (or more electronegative element) is always written second. Its ending changes to *-ide*. For example, hydrogen changes to *hydride*, carbon changes to *carbide*, sulfur changes to *sulfide*, and iodine changes to *iodide*.

Putting It All Together

To name a binary compound containing metal and a non-metal, write the name of the metal first and the name of the non-metal second. For example, a compound that contains potassium as the cation and bromine as the anion is called *potassium bromide*. Be sure to indicate the valence if necessary, using the Stock system. For example, a compound that contains Pb^{2+} and oxygen is called *lead(II) oxide*.

Practice Problems

20. Write the IUPAC name for each compound.

(a) Al_2O_3 **(d)** Cu_2S

(b) $CaBr_2$ **(e)** Mg_3N_2

(c) Na_3P **(f)** HgI_2

21. Write the formula of each compound.

(a) iron(II) sulfide **(d)** cobaltous chloride

(b) stannous oxide **(e)** manganese(II) iodide

(c) chromium(II) oxide **(f)** zinc oxide

Naming Compounds That Contain Hydrogen

If a binary compound contains hydrogen as the less electronegative element, "hydrogen" is used first in the name of the compound. For example, HCl is called *hydrogen chloride* and H_2S is called *hydrogen sulfide*. Sometimes hydrogen can be the anion, usually in a compound that contains a Group 1 metal. If hydrogen is the anion, its ending must be changed to -*ide*. For example, NaH is called *sodium hydride* and LiH is called *lithium hydride*. Hydrogen-containing compounds can also be formed with the Group 15 elements. These compounds are usually referred to by their common names as opposed to their IUPAC names. For example, NH_3 is called *ammonia*, PH_3 is called *phosphine*, AsH_3 is called *arsine*, and SbH_3 is called *stibine*.

Many compounds that contain hydrogen are also acids. For example, H_2SO_4, hydrogen sulfate, is also called sulfuric acid. You will learn about acid nomenclature in Chapter 10.

Practice Problems

22. Write the IUPAC name for each compound.

(a) H_2Se
(b) HCl
(c) HF
(d) LiH
(e) CaH_2
(f) PH_3

Naming Compounds That Contain Polyatomic Ions

Many compounds contain one or more polyatomic ions. Often these compounds contain three elements, in which case they are called **tertiary compounds**. Although they are not binary compounds, they still contain one type of anion and one type of cation. The same naming rules that apply to binary compounds apply to these compounds as well. For example, NH_4Cl is called *ammonium chloride*. Na_2SO_4 is called *sodium sulfate*. $NiSO_4$ is called *nickel(II) sulfate*. NH_4NO_3 is called *ammonium nitrate*.

The non-metals in the periodic table are greatly outnumbered by the metals. There are many negatively charged polyatomic ions, however, to make up for this. In fact, polyatomic anions are commonly found in everyday chemicals. Refer back to Table 3.4 for the names of the most common polyatomic anions.

When you are learning the names of polyatomic ions, you will notice a pattern. For example, consider the polyatomic ions that contain chlorine and oxygen:

ClO^-	hypochlorite
ClO_2^-	chlorite
ClO_3^-	chlorate
ClO_4^-	perchlorate

Can you see the pattern? Each ion has the same valence, but different numbers of oxygen atoms. The base ion is the one with the "ate" ending chlorate. It contains three oxygen atoms. When the ending is changed to "ite," subtract an oxygen atom from the chlorate ion. The resulting chlorite ion contains two oxygen atoms. Add "hypo" to "chlorite," and subtract one more oxygen atom. The resulting hypochlorite ion has one oxygen atom. Adding "per" to "chlorate," means that you should add an oxygen to the chlorate ion. The perchlorate ion has four oxygen atoms.

The base "ate" ions do not always have three oxygen atoms like chlorate does. Consider the polyatomic ions that contain sulfur and oxygen. In this case, the base ion, sulfate, SO_4^{2-}, contains four oxygen atoms. The sulfite ion, SO_3^{2-}, therefore contains three oxygen atoms. The hyposulfite ion, SO_2^{2-}, contains two oxygen atoms. Once you know the meanings of the prefixes and suffixes, you need only memorize the formulas of the "ate" ions. You can work out the formulas for the related ions using their prefixes and suffixes. The meanings of the prefixes and suffixes are summarized in Table 3.7. In this table, the "*x*" stands for the number of oxygen atoms in the "ate" ion.

Table 3.7 Meaning of prefixes and suffixes

Prefix and suffix			Number of oxygen atoms
hypo		ite	$x - 2$ oxygen atoms
		ite	$x - 1$ oxygen atoms
		ate	x oxygen atoms
per		ate	$x + 1$ oxygen atoms

Language LINK

The prefix "thio" in the name of a polyatomic ion means that an oxygen atom in the root "ate" ion has been replaced by a sulfur atom. For example, the sulfate ion is SO_4^{2-}, while the thiosulfate ion is $S_2O_3^{2-}$. Notice that the valence does not change.

Practice Problems

23. Write the IUPAC name for each compound.

(a) $(NH_4)_2SO_3$
(b) $Al(NO_2)_3$
(c) Li_2CO_3
(d) $Ni(OH)_2$
(e) Ag_3PO_4
(f) $Cu(CH_3COO)_2$

Naming Binary Compounds That Contain Two Non-Metals

To indicate that a binary compound is made up of two non-metals, a prefix is usually added to both non-metals in the compound. This prefix indicates the *number of atoms of each element* in one molecule or formula unit of the compound. For example, P_2O_5 is named *diphosphorus pentoxide*. Alternatively, the Stock System may be used, and P_2O_5 can be named *phosphorus (V) oxide*. $AsBr_3$ is named phosphorus tribromide. The prefix *mono-* is often left out when there is only one atom of the first element in the name. A list of numerical prefixes is found in Table 3.8.

Table 3.8 Numerical Prefixes for Binary Compounds That Contain Two Non-Metals

Number	Prefix
1	mono-
2	di-
3	tri-
4	tetra-
5	penta-
6	hexa-
7	hepta-
8	octa-
9	nona-
10	deca-

Practice Problems

24. Write the IUPAC name for each compound.

(a) SF_6
(b) N_2O_5
(c) PCl_5
(d) CF_4

Section Wrap-up

In section 3.4, you learned how to name ionic and covalent compounds. You also learned how to write their formulas. In Chapter 4, you will learn how compounds and elements interact in nature, in the laboratory, and in everyday life. These interactions are responsible for the tremendous variety of substances and materials found on Earth.

Section Review

1 K/U Write an unambiguous name for each compound.

(a) K_2CrO_4

(b) NH_4NO_3

(c) Na_2SO_4

(d) $Sr_3(PO_4)_2$

(e) KNO_2

(f) $Ba(ClO)_2$

2 K/U Write the name of each binary compound.

(a) $MgCl_2$

(b) Na_2O

(c) $FeCl_3$

(d) CuO

(e) ZnS

(f) $AlBr_3$

3 K/U Write the formula of each compound.

(a) sodium hydrogen carbonate

(b) potassium dichromate

(c) sodium hypochlorite

(d) lithium hydroxide

(e) potassium permanganate

(f) ammonium chloride

(g) calcium phosphate

(h) sodium thiosulfate

4 K/U Write the formula and name of two possible compounds that could be formed from each pair of elements.

(a) vanadium and oxygen

(b) iron and sulfur (–2)

(c) nickel and oxygen

5 C The formula for hydrogen peroxide is H_2O_2. Explain why it is not correct to write the formula for this covalent compound as HO.

Unit Project Prep

In this section, you saw some common names for chemicals. Before you begin your Unit Project, create a list of names of chemicals found in common household cleaning products. If you know only the common name, find out the chemical name.