SECTION 2.2

Writing Names and Formulas for Ionic and Molecular Compounds

Key Terms

alkali
oxoacid
structural formula

"Please pass the sodium chloride."

"Do you have enough sucrose for your tea?"

"May I please have some more dihydrogen monoxide?"

"These biscuits are so hard and flat! I must have forgotten to put the sodium hydrogen carbonate in the dough."

You might have heard statements like these while having a meal with family or friends, as in **Figure 2.20**, but the terminology was probably quite different. Four of the terms in these statements are chemical names for common substances. Do you know what the substances are? In this section, you will learn how to name and write the formulas for ionic and molecular compounds. As you read this section, try to figure out the common names for the chemicals identified in the earlier statements.

Figure 2.20 Would other friends or family members know what you meant if you asked, "May I please have some more dihydrogen monoxide?" during a meal?

Standardized Naming

Imagine sitting at a table with six people, all of whom speak a different language. If you said, "Please pass the potatoes," no one would know what you wanted. Someone else might say "Kartoffel?" but you would probably not know what he or she meant.

Chemistry is a language that has millions of "words." Chemists had begun to recognize the need to "speak the same language" as early as the late 1700s. Several chemistry organizations began to develop rules for naming compounds. The current standards are set by the International Union for Pure and Applied Chemistry (IUPAC). The organization was founded in 1919 and still holds meetings to maintain and improve on the rules that allow chemists throughout the world to communicate clearly and concisely.

Naming Binary Ionic Compounds

Binary compounds are among the simplest compounds to name. A *binary ionic compound* is an ionic compound that consists of atoms of only two (bi-) different elements. Because ionic compounds nearly always consist of metals and non-metals, one of these two elements must be a metal and the other must be a non-metal. Study the steps below to review the rules for naming binary ionic compounds.

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Rules for Naming Binary Ionic Compounds

1. The name of the metal ion is first, followed by the name of the non-metal ion.
2. The name of the metal ion is the same as the name of the metal atom.
3. If the metal is a transition metal, it might have more than one possible charge. In these cases, a roman numeral is written in brackets after the name of the metal to indicate the magnitude of the charge.
4. The name of the non-metal ion has the same root as the name of the atom, but the suffix is changed to *-ide*.

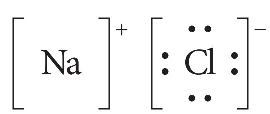
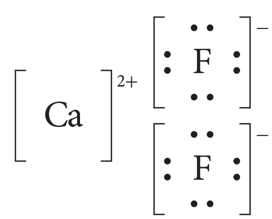
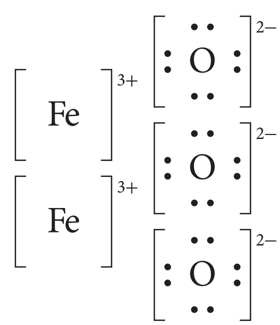
The names of several common non-metal ions are listed in **Table 2.2**.

As you learned in Section 2.1, when forming an ionic compound, the positive and negative ions must combine in numbers that result in a zero net charge. There is no need to indicate these numbers in the name, however, because they are determined by the charges on the ions. The examples in **Table 2.3** will help you review the rules for naming binary ionic compounds, starting with Lewis diagrams.

Table 2.2 Names of Some Common Non-metal Ions

Formula for Ion	Name of Ion
F^-	fluoride
Cl^-	chloride
Br^-	bromide
I^-	iodide
O^{2-}	oxide
S^{2-}	sulfide
N^{3-}	nitride

Table 2.3 Examples of Naming Binary Ionic Compounds

Compound			
Steps			
1. Name the metal ion first.	The metal is sodium.	The metal is calcium.	The metal is iron.
2. The name of the ion is the same as the name of the metal.	The name of the sodium ion is *sodium*.	The name of the calcium ion is *calcium*.	The name of the iron ion is *iron*.
3. If the metal ion can have more than one charge, indicate the charge with a roman numeral in brackets.	Sodium ions always have a charge of 1+ so no roman numeral is needed.	Calcium ions always have a charge of 2+ so no roman numeral is needed.	Iron ions can have a charge of 2+ or 3+. The Lewis diagram shows that the iron ions have a charge of 3+, so the roman numeral III must be added. The name of the metal ion becomes *iron(III)*.
4. Name the non-metal ion second. Use the root name of the atom with the suffix *-ide*.	The non-metal is chlorine. Change *chlorine* to *chloride*. Add the name chloride to sodium. The name of the compound is **sodium chloride**.	The non-metal is fluorine. Change *fluorine* to *fluoride*. Add the name fluoride to calcium. The name of the compound is **calcium fluoride**.	The non-metal is oxygen. Change *oxygen* to *oxide*. Add the name oxide to iron(III). The name of the compound is **iron(III) oxide**.

Naming Ionic Compounds with Polyatomic Ions

The rules for naming ionic compounds that have polyatomic ions are fundamentally the same as the rules for naming binary ionic compounds. Each polyatomic ion that you encounter has its own name and is treated as a single unit in a compound. The names and structures of all of the polyatomic ions that you are likely to encounter are listed in **Table 2.4**. Recall that the only common positively charged polyatomic ion is the ammonium ion, NH_4^+, which you saw in **Figure 2.15**.

Table 2.4 Some Common Polyatomic Ions

Name	Formula	Name	Formula
ammonium	NH_4^+	nitrate	NO_3^-
acetate or ethanoate	CH_3COO^-	nitrite	NO_2^-
benzoate	$C_6H_5COO^-$	oxalate	$OOCCOO^{2-}$
borate	BO_3^{3-}	hydrogen oxalate	$HOOCCOO^-$
carbonate	CO_3^{2-}	permanganate	MnO_4^-
hydrogen carbonate	HCO_3^-	phosphate	PO_4^{3-}
perchlorate	ClO_4^-	hydrogen phosphate	HPO_4^{2-}
chlorate	ClO_3^-	dihydrogen phosphate	$H_2PO_4^-$
chlorite	ClO_2^-	sulfate	SO_4^{2-}
hypochlorite	ClO^-	hydrogen sulfate	HSO_4^-
chromate	CrO_4^{2-}	sulfite	SO_3^{2-}
dichromate	$Cr_2O_7^{2-}$	hydrogen sulfite	HSO_3^-
cyanide	CN^-	cyanate	CNO^-
hydroxide	OH^-	thiocyanate	SCN^-
iodate	IO_3^-	thiosulfate	$S_2O_3^{2-}$

There are no comprehensive rules for naming polyatomic ions, so it is best just to learn the names. There are some generalizations, however, that will help you remember some of the names. If you read through the names and structures in **Table 2.4**, you will notice that several groups, or families, of polyatomic ions have names with similar roots and have compositions that vary only in the number of oxygen atoms. **Table 2.5** lists the prefixes and suffixes and shows how they are assigned to each family of ions.

Table 2.5 Prefixes and Suffixes for Families of Polyatomic Ions

Relative Number of Oxygen Atoms	Prefix	Suffix	Example	
Family of Four				
most	per-	-ate	ClO_4^-	perchlorate
second most	(none)	-ate	ClO_3^-	chlorate
second fewest	(none)	-ite	ClO_2^-	chlorite
fewest	hypo-	-ite	ClO^-	hypochlorite
Family of Two				
most	(none)	-ate	NO_3^-	nitrate
fewest	(none)	-ite	NO_2^-	nitrite

It is important to notice that the suffix, *-ate* or *-ite*, does not specify a certain number of oxygen atoms. Instead it indicates the relative number of oxygen atoms. For example, nitrate has three oxygen atoms and nitrite has two oxygen atoms, whereas sulfate has four oxygen atoms and sulfite has three oxygen atoms.

In **Table 2.4**, you will also notice that some polyatomic ions with a charge of 2− or 1− have *hydrogen* or *dihydrogen* at the beginning of their name. This term describes the number of hydrogen ions added to the original polyatomic ion. For example, the phosphate ion, PO_4^{3-}, has no hydrogen ions. Hydrogen phosphate, HPO_4^{2-}, has one hydrogen ion and one less negative charge than the phosphate ion. Dihydrogen phosphate, $H_2PO_4^{-}$, has two hydrogen ions and two fewer negative charges than the phosphate ion.

As well, you will notice the prefix *thio-* in front of two of the polyatomic ions. This prefix indicates that a sulfur atom has taken the place of an oxygen atom. For example, the sulfate ion, SO_4^{2-}, has one sulfur atom and four oxygen atoms. The thiosulfate ion, $S_2O_3^{2-}$, has two sulfur atoms and three oxygen atoms.

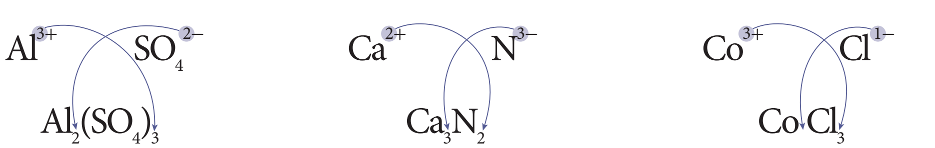
Writing Chemical Formulas for Ionic Compounds

A chemical name provides all the information that you need to write the chemical formula for a compound. The following steps summarize the rules for writing the chemical formulas for ionic compounds.

Rules for Writing Chemical Formulas for Ionic Compounds

1. Identify the positive ion and the negative ion.
2. Find the chemical symbols for the ions, either in the periodic table or in the table of polyatomic ions. Write the symbol for the positive ion first and the symbol for the negative ion second.
3. Determine the charges of the ions. If you do not know the charges, you can find them in the periodic table on page 24.
4. Check to see if the charges differ. If the magnitudes of the charges are the same, the formula is complete. If they differ, determine the number of each ion that is needed to create a zero net charge. Write the numbers of ions needed as subscripts beside the chemical symbols, with one exception. When only one ion is needed, leave the subscript blank. A blank means one. If a polyatomic ion needs a subscript, the formula for the ion must be in brackets and the subscript must be outside the brackets.

When the charges of the ions are not the same, you have to determine the number of each ion that is needed to create a zero net charge. To do this, you could simply "guess and check." However, the cross-over method shown in **Figure 2.21** is a more direct way to determine the number of each ion that is needed. As shown in **Figure 2.21**, use the magnitude of the charge of each ion as the subscript for the opposite ion. Below each diagram is a calculation that demonstrates why the subscripts always give you the numbers of ions that result in a zero net charge for the compound. **Table 2.6**, on the next page, shows examples of applying the rules for writing formulas for ionic compounds.



$2(+3) + 3(-2) = 6 - 6 = 0$ $3(+2) + 2(-3) = 6 - 6 = 0$ $1(+3) + 3(-1) = 3 - 3 = 0$

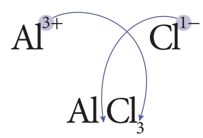
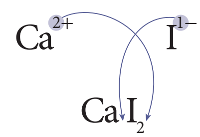
Figure 2.21 When you make the number of ions of each element (the subscript) equal in magnitude to the charge of the opposite ion, you will create a compound with a zero net charge.

Notice, in the first example in **Figure 2.21**, that you use only the net charge and ignore the subscript on the polyatomic ion. Also note that the new subscript that indicates the number of polyatomic ions in the compound goes outside the brackets.

Examples of Using Rules for Formulas for Ionic Compounds

The following examples will show you how the rules are applied to writing formulas for ionic compounds.

Table 2.6 Examples of Writing Formulas for Ionic Compounds

Steps \ Name	aluminum chloride	calcium iodide	potassium permanganate
1. Identify the positive ion and the negative ion.	Aluminum is first, so it is the positive ion. Chloride is second and has the suffix *-ide*, so it is the negative ion.	Calcium is first, so it is the positive ion. Iodide is second and has the suffix *-ide*, so it is the negative ion.	Potassium is first, so it is the positive ion. Permanganate is second, so it is the negative ion. It does not end with *-ide*, so it is a polyatomic negative ion.
2. Find the chemical symbols for the ions. Write the symbol for the positive ion first and the symbol for the negative ion second.	The symbol for aluminum is Al, and the symbol for chloride is Cl. The formula without subscripts is *Al_Cl_*.	The symbol for calcium is Ca, and the symbol for iodide is I. The formula without subscripts is *Ca_I_*.	The symbol for potassium is K, and the symbol for permanganate is MnO_4. The formula without subscripts is *K_*MnO_4*_*.
3. Determine the charges of the ions.	The aluminum ion has a charge of 3+, and the chloride ion has a charge of 1−.	The calcium ion has a charge of 2+, and the iodide ion has a charge of 1−.	The potassium ion has a charge of 1+, and the permanganate ion has a charge of 1−.
4. Check to see if the charges differ. If the charges are the same, the formula is complete. If they differ, determine the number of each ion that is needed to create a zero net charge. Write the numbers of ions needed as subscripts beside the chemical symbols.	The charges differ, so use the method in **Figure 2.21** to find the number of ions needed.  You need three chloride ions for one aluminum ion. The formula is $\mathbf{AlCl_3}$.	The charges differ, so use the method in **Figure 2.21** to find the number of ions needed.  You need two iodide ions for one calcium ion. The formula is $\mathbf{CaI_2}$.	The charges are the same, so the formula is $\mathbf{KMnO_4}$.

Writing Names and Formulas for Acids and Bases

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Acids are compounds that ionize, or come apart, in water and release a hydrogen ion, H^+. Thus, the positive ion in acids is the hydrogen ion. For example, on page 62, you read that when HCl dissolves in water, it separates into a hydrogen ion, H^+, and a chloride ion, Cl^-.

Bases are compounds that produce a *hydroxide ion*, OH^-, when they dissolve in water. Thus, the negative ion in bases is usually the hydroxide ion. Notice that the hydroxide ion was listed in **Table 2.4** among the polyatomic ions. Sodium hydroxide, NaOH(s), is a common example of a base. When NaOH(s) dissolves in water, it separates into a sodium ion, Na^+, and a hydroxide ion, OH^-.

Naming and Writing Formulas for Bases

The rules for naming bases and for writing their formulas are the same as the rules for naming and writing formulas for all other ionic compounds. For example, NaOH is sodium hydroxide because Na^+ is the metal ion and the name of the ion is the same as the name of the metal. Hydroxide is the name of the polyatomic ion, OH^-. Thus, any compound with a metal ion or a positively charged polyatomic ion combined with the hydroxide ion is a base. Pure bases are often solids. You can distinguish between the pure base and the basic solution simply by noting its state, which is often indicated by a symbol in brackets after the formula. For example, NaOH(s), where (s) represents solid, is the pure compound. NaOH(aq), where (aq) means “aqueous solution,” is the solution of sodium hydroxide in water.

Terminology Involving Bases

The term **alkali** is often used to refer to a base that is soluble in water. This term comes from soap making in the Middle East thousands of years ago. Warm water was poured on the ashes from burnt wood or dried plants, dissolving the bases that were in the ashes. The resulting solution was then boiled with animal fats to make soap. The Arabic word *al-qali* means "the ashes." The earliest records of soap making date from around 2800 BCE in ancient Babylonia, which is now part of Iraq.

alkali a base that is soluble in water

You probably recognize the term alkali from the Group 1 metals in the periodic table, which are called alkali metals. As you know, the alkali metals react violently with water. One of the products of that reaction is the hydroxide of the alkali metal, which is a base that is dissolved in water.

Naming and Writing Formulas for Acids

Acids, in their pure form, are molecular compounds. However, they are named according to the rules for ionic compounds. For example, pure HCl is hydrogen chloride. Hydrogen is named as though it was the positively charged ion and its name is not changed. Chloride is named as though it was the negatively charged ion. The rules for writing formulas for acids are the same as the rules for writing formulas for other ionic compounds.

When an acid is dissolved in water, the name is changed. The current naming system recommended by IUPAC is relatively new and the older, classical naming system is used so frequently that it is helpful to learn both systems. In the IUPAC naming system, the name of the pure acid is simply preceded by the term "aqueous." For example, when hydrogen chloride is dissolved in water, it becomes aqueous hydrogen chloride. The classical names, however, are not quite as simple. To learn the classical names, it is convenient to separate acids into two categories, those that contain oxygen and those that do not.

Acids That Do Not Contain Oxygen

The classical name for acids that do not contain oxygen is formed by omitting the word hydrogen, adding the prefix *hydro-* and the suffix *-ic* and *acid* to the root name. For example, hydrogen chloride becomes hydrochloric acid. **Table 2.7** lists some examples.

Table 2.7 Names of Some Common Acids without Oxygen

Pure Substance (name)	Formula H(negative ion)(aq)	Classical Name hydro(root)ic acid	IUPAC Name aqueous hydrogen (negative ion)
hydrogen fluoride	HF(aq)	hydrofluoric acid	aqueous hydrogen fluoride
hydrogen cyanide	HCN(aq)	hydrocyanic acid	aqueous hydrogen cyanide
hydrogen sulfide	H_2S(aq)	hydrosulfuric acid	aqueous hydrogen sulfide

Notice, in **Table 2.7**, that all of the examples except HCN are binary acids. That is, they contain only hydrogen and a non-metal.

Acids That Contain Oxygen

Acids that contain oxygen are called **oxoacids**. They are composed of hydrogen, oxygen, and atoms of at least one other element, which is usually, but not always, a non-metal. The combination of oxygen and an atom of another element is essentially, a negatively charged polyatomic ion. In fact, almost any of the negatively charged polyatomic ions in **Table 2.4** can be found in acids. However, notice what would happen if you combined a hydrogen ion with a hydroxide ion, which is a polyatomic ion. You would have HOH, which is water.

oxoacid an acid composed of hydrogen, oxygen, and atoms of at least one other element

Naming Oxoacids

The rules for determining IUPAC names for oxoacids are the same as the rules for naming acids with no oxygen atoms. To learn the classical naming system, you need to refer to the system for naming polyatomic ions with varying numbers of oxygen atoms in **Table 2.5**. Just as there are families of ions with varying numbers of oxygen atoms, there are families of acids with varying numbers of oxygen atoms. **Table 2.8** relates the prefixes and suffixes of the polyatomic ions to those of the corresponding acids. Notice that the prefixes remain the same while the suffix *-ite* changes to *-ous acid* and the suffix *-ate* changes to *-ic acid*.

Table 2.8 Classical Naming System for Families of Oxoacids

		Examples	
Name of Ion	**Name of Acid (dissolved in water)**	**Name of Ion**	**Name of Acid (dissolved in water)**
hypo(root)ite	hypo(root)ous acid	hypochlorite, ClO^-	hypochlorous acid, HClO
(root)ite	(root)ous acid	chlorite, ClO_2^-	chlorous acid, $HClO_2$
(root)ate	(root)ic acid	chlorate, ClO_3^-	chloric acid, $HClO_3$
per(root)ate	per(root)ic acid	perchlorate, ClO_4^-	perchloric acid, $HClO_4$

To name other oxoacids, look for the prefix (if any) and the suffix and match them to the prefix (if any) and suffix of the acid in **Table 2.8**. For example, the ion nitrate has no prefix and the suffix is *-ate*. The acid would then have no prefix and would have the suffix *-ic acid*. The name of the pure substance, hydrogen nitrate, when dissolved in water would be nitric acid. When the ion already includes one hydrogen atom, such as hydrogen carbonate, HCO_3^-, simply add another hydrogen, $H_2CO_3(aq)$. The name of the ion would be carbonate, and the acid would be carbonic acid.

Learning Check

7. What is a binary ionic compound?

8. Write the names and chemical formulas for the compounds containing the following.
- **a.** potassium and sulfur
- **b.** oxygen and magnesium
- **c.** chlorine and iron
- **d.** magnesium and nitrogen
- **e.** hydrogen and iodine
- **f.** calcium and hydroxide ion

9. Write the name of each compound.
- **a.** $CrBr_2$ **c.** HgCl **e.** $HNO_3(aq)$
- **b.** Na_2S **d.** PbI_2 **f.** KOH

10. Write the chemical formula for each compound.
- **a.** zinc bromide **d.** magnesium chloride
- **b.** aluminum sulfide **e.** hydrogen nitride
- **c.** copper(II) nitride **f.** copper(II) hydroxide

11. The root of the names of the following ions is *fluor*. Name each ion, and explain how you decided on the name.
- **a.** FO^- **b.** FO_2^- **c.** FO_3^- **d.** FO_4^-

12. Write the chemical formula for each compound.
- **a.** iron(II) sulfate **d.** magnesium phosphate
- **b.** sodium nitrate **e.** hydrogen carbonate
- **c.** copper(II) chromate **f.** aluminum hydroxide

Writing Names and Formulas for Binary Molecular Compounds

The names of molecular compounds include more details than the names of ionic compounds, because non-metals can combine in a variety of ratios. For example, nitrogen and oxygen can combine to form six different molecular compounds: NO, NO_2, N_2O, N_2O_3, N_2O_4, and N_2O_5. Clearly, the name *nitrogen oxide* could mean any of these compounds. The rules for naming binary molecular compounds make it possible for each compound to have its own name, which clearly describes the numbers of atoms in the compound. These rules are listed on the following page.

Naming Binary Molecular Compounds

The rules listed below explain how to name binary molecular compounds. The prefixes that are used for naming these compounds are listed in **Table 2.9**. Three examples follow, in **Table 2.10**.

Table 2.9 Prefixes for Binary Molecular Compounds

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

Rules for Naming Binary Molecular Compounds

1. Name the element with the lower group number first. Name the element with the higher group number second.
2. The one exception to the first rule occurs when oxygen is combined with a halogen. In this situation, the halogen is named first.
3. If both elements are in the same group, name the element with the higher period number first.
4. The name of the first element is unchanged.
5. To name the second element, use the root name of the element and add the suffix *-ide*.
6. If there are two or more atoms of the first element, add a prefix to indicate the number of atoms.
7. Always add a prefix to the name of the second element to indicate the number of atoms of this element in the compound. (If the second element is oxygen, an "o" or "a" at the end of the prefix is usually omitted.)

Table 2.10 Examples of Naming Molecular Compounds

Steps / Atoms in Compound	two nitrogen atoms and one oxygen atom	five iodine atoms and one phosphorus atom	two chlorine atoms and seven oxygen atoms
1. Name the element with the lower group number (to the left in the periodic table) first. Name the element with the higher group number (to the right in the periodic table) second. **2.** The one exception to the first rule occurs when oxygen is combined with a halogen. In this situation, the halogen is named first. **3.** If both elements are in the same group, name the element with the higher period number first.	Nitrogen is in Group 15 and oxygen is in Group 16, so nitrogen comes first. ***_nitrogen _oxygen***	Iodine is in Group 17 and phosphorus is in Group 15, so phosphorus comes first. ***_phosphorus _iodine***	Chlorine is in Group 17 and oxygen is in Group 16, so oxygen should be first and chlorine should be second. However, when oxygen is combined with a halogen, the halogen is named first. ***_chlorine _oxygen***
4. The name of the first element is unchanged. **5.** To name the second element, use the root name of the element and add the suffix *-ide*.	The name *nitrogen* is unchanged, but *oxygen* is changed to *oxide*. ***_nitrogen _oxide***	The name *phosphorus* is unchanged, but *iodine* is changed to *iodide*. ***_phosphorus _iodide***	The name *chlorine* is unchanged, but oxygen is changed to *oxide*. ***_chlorine _oxide***
6. If there are two or more atoms of the first element, add a prefix to indicate the number of atoms. **7.** Always add a prefix to the name of the second element to indicate the number of atoms of this element in the compound. (If the second element is oxygen, an "o" or "a" at the end of the prefix is usually omitted.)	There are two nitrogen atoms, so the prefix is *di-*. There is one oxygen atom, so the prefix is *mono-*. Because the second element is oxygen, use *mon-*. The name of the compound is **dinitrogen monoxide**.	There is only one phosphorus atom, so no prefix is added. There are five iodine atoms, so the prefix is *penta-*. The name of the compound is **phosphorus pentaiodide**.	There are two chlorine atoms, so the prefix *di-* is added. There are seven oxygen atoms so the prefix should be *hepta-*. However, the second element is oxygen so the "a" on *hepta-* is omitted. The prefix is *hept-*. The name of the compound is **dichlorine heptoxide**.

Writing Chemical Formulas for Binary Molecular Compounds

An important exception to all of the rules for naming and writing formulas for binary molecular compounds occurs when the two elements in a compound are carbon and hydrogen. Combinations of carbon and hydrogen constitute a large group of compounds called hydrocarbons, which are a subgroup of a larger group of compounds called organic compounds. Organic compounds consist of all compounds that contain carbon atoms, other than carbon monoxide (CO), carbon dioxide (CO_2), carbonates (CO_3^{2-}), cyanides (CN^-), and carbides (several forms). Organic compounds have a unique naming system. You will study organic chemistry in more advanced chemistry courses. The following rules apply to inorganic compounds, which are all compounds other than organic compounds. **Table 2.11** provides three examples of naming binary molecular compounds.

Rules for Writing Chemical Formulas for Binary Molecular Compounds

1. Write the symbol for the element with the lowest group number first.
2. Write the symbol for the element with the highest group number second.
3. The one exception to the first two rules occurs when oxygen is combined with a halogen. In this case, the symbol for the halogen is written first.
4. If both elements are in the same group, write the symbol for the one with the higher period number first.
5. If the number of atoms of either or both elements is greater than one, write the number as a subscript beside the symbol. The absence of a subscript is understood to mean one.

Table 2.11 Examples of Writing Chemical Formulas for Binary Molecular Compounds

Steps / Atoms in Compound	two nitrogen atoms and one oxygen atom	two chlorine atoms and one oxygen atom	four bromine atoms and one silicon atom
1. Write the symbol for the element with the lowest group number first. **2.** Write the symbol for the element with the highest group number second.	Nitrogen is in Group 15 and oxygen is in Group 16, so the symbol for nitrogen is written first. ***N_O_***	Chlorine is in Group 17 and oxygen is in Group 16, so the symbol for oxygen should be written first. ***O_Cl_***	Bromine is in Group 17 and silicon is in Group 14, so the symbol for silicon is written first. ***Si_Br_***
3. The one exception to the first two rules occurs when oxygen is combined with a halogen. In this case, the symbol for the halogen is written first. **4.** If both elements are in the same group, write the symbol for the one with the higher period number first.	Oxygen is not combined with a halogen. Oxygen and nitrogen are not in the same group. No changes are needed. ***N_O_***	Oxygen is combined with the halogen chlorine, so the symbol for chlorine comes first. ***Cl_O_***	Oxygen is not in the compound. Silicon and bromine are not in the same group. No changes are needed. ***Si_Br_***
5. If the number of atoms of either or both elements is greater than one, write the number as a subscript beside the symbol. The absence of a subscript is understood to mean one.	There are two nitrogen atoms, so the subscript *2* is written beside *N*. There is only one oxygen atom, so there is no subscript beside *O*. The formula is N_2O.	There are two chlorine atoms, so the subscript *2* is written beside *Cl*. There is only one atom of oxygen, so there is no subscript beside *O*. The formula is Cl_2O.	There is one silicon atom, so there is no subscript beside *Si*. There are four bromine atoms, so the subscript 4 is written beside *Br*. The formula is $SiBr_4$.

Sample Problem

Names from Formulas and Formulas from Names

Problem

Write the names of the compounds for parts *a* and *b*. Write the formulas for parts *c* and *d*.

a. SF_6 **b.** $Cu(NO_3)_2$ **c.** aluminum sulfide **d.** sulfur trioxide

What Is Required?

You need to determine the names of SF_6 and $Cu(NO_3)_2$
You also need to determine the formulas for aluminum sulfide and sulfur trioxide.

What Is Given?

You are given the formulas for two compounds: SF_6 and $Cu(NO_3)_2$
You are given the names of two compounds: aluminum sulfide and sulfur trioxide

Plan Your Strategy	Act on Your Strategy
a. SF_6 S is sulfur and F is fluorine. They are both non-metals so the compound is molecular and you need prefixes. Fluorine is the second element so you change the ending to *–ide*.	_sulfur _fluoride
There is one sulfur atom so the prefix would be *mono*. However, it is the first element so no prefix is needed. There are six fluorine atoms so the prefix is *hexa-*.	**sulfur hexafluoride**
b. $Cu(NO_3)_2$ Cu is copper and it is a metal. NO_3 is a polyatomic ion and the name is nitrate. The compound is ionic so you do not need prefixes.	copper_ nitrate
A copper ion can have a charge of 1+ or 2+. Nitrate has a charge of 1− and there are two of the ions. Therefore the copper ion must have a charge of 2+ to make the compound neutral. Add (II) to the name of copper.	**copper(II) nitrate**
c. aluminum sulfide Aluminum is a metal. Its symbol is Al. Its charge is 3+. Sulfur is a non-metal. Its symbol is S. Its charge is 2−.	$Al^{3+}S^{2-}$
The charges are not the same so you need subscripts. The subscript (number of atoms) of each element is the same as the magnitude of the charge of the other ion.	**Al_2S_3**
d. sulfur trioxide Sulfur and oxygen are both non-metals, so the compound is molecular. You need subscripts. The symbol for sulfur is S. The symbol for oxygen is O.	S_O_
Sulfur has no prefix, so the number of atoms is assumed to be one and therefore no subscript is needed. Oxygen has the prefix *tri-*, meaning there are three oxygen atoms. Its subscript is 3.	**SO_3**

Check Your Solution

When you add up the charges on the ionic compounds, they add up to zero. The names and symbols for the molecular compounds describe the same number of atoms of the same elements.

Practice Problems

1. Write the name of P_4S_7.
2. Write the name of $Pb(NO_3)_2$.
3. Write the formula for manganese(IV) chloride.
4. Write the formula for nitrogen triiodide.
5. Write the name of CuBr.
6. Write the formula for iron(III) oxide.
7. Write the formula for silicon dioxide.
8. Write the name of SeF_6.
9. Write the name of CaO.
10. Write the formula for cobalt(III) nitrate.

Drawing Structural Formulas for Molecular Compounds

structural formula a diagram that has the chemical symbols connected by lines to show the connections among atoms in a chemical compound

A chemical name or formula tells you how many atoms of each element are in a molecule. However, it does not provide information about how the atoms are bonded to one another. A Lewis structure shows you how the atoms are connected to each other, but it is cumbersome to draw. Because chemists need an easier way to show the connections between atoms, they developed structural formulas. You can draw a **structural formula** from a Lewis structure by drawing a single line to represent a pair of bonding electrons and omitting the lone pairs. Thus, one straight line represents one bond. **Figure 2.22** shows some Lewis structures you have seen before, as well as some new Lewis structures, along with their structural formulas.

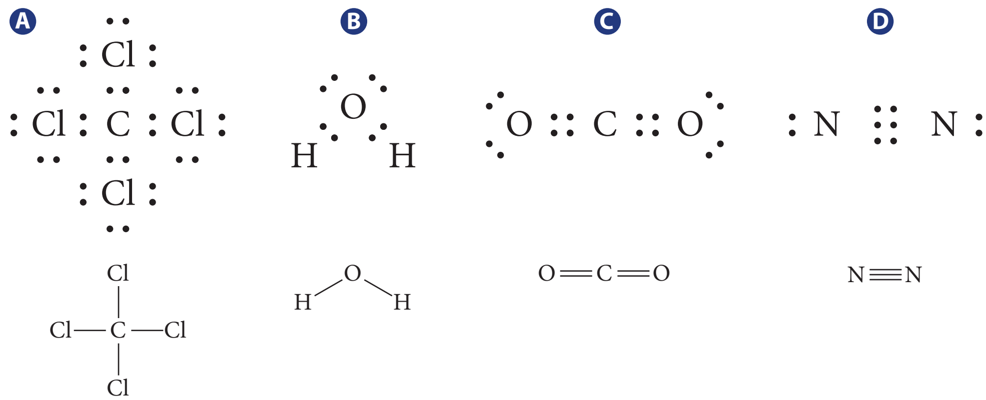

Figure 2.22 Compound **(A)** is carbon tetrachloride. Instead of drawing 32 dots, as you would for a Lewis structure, you need to draw only four lines for a structural formula. Compound **(B)** is dihydrogen monoxide. Compound **(C)** is carbon dioxide. Notice that the double bonds are drawn as two lines. Compound **(D)** is nitrogen, which has a triple bond.

***State** the common name for dihydrogen monoxide.*

Suggested Investigation

Inquiry Investigation 2-B, Building Molecular Models

Although structural formulas provide more information than the simpler chemical formulas, they are still only two-dimensional, while real molecules are three-dimensional. Thus, to visualize a molecule completely, you need to build a model. You can use something as simple as toothpicks and Styrofoam® balls to build three-dimensional models. You can also use kits that have different sizes and colours of balls to represent atoms of different elements. Regardless of the materials, these models can help you visualize and analyze molecules.

Building your own models gives you an understanding of the three-dimensional structure of molecules that you cannot attain any other way. However, modern computers can now generate molecular models of very small to very large molecules. The image in **Figure 2.23** is a space-filling model. The relative sizes of the spheres and the way they fit together is an excellent representation of the shape of the actual molecule.

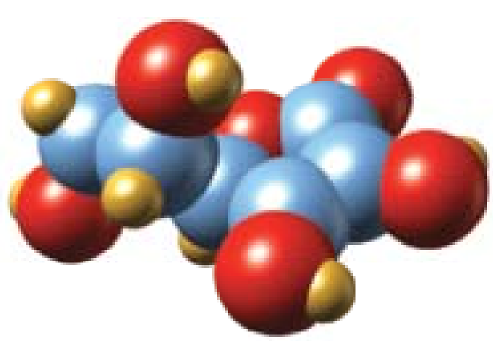

Figure 2.23 This is a computer-generated model of ascorbic acid (vitamin C), $C_6H_8O_6$.

Section 2.2 REVIEW

Section Summary

- The name of a binary ionic compound starts with the name of the metal element and, if necessary, a roman numeral indicating the charge on the ion. This is followed by the name of the non-metal element with the ending changed to *-ide*.
- The formula for a binary ionic compound starts with the symbol for the metal element followed by the symbol for the non-metal element. Subscripts indicate the numbers of atoms of the two elements.
- Bases are named according to the rules for ionic compounds.
- When acids are dissolved in water, they are named according to different rules than when they are in their pure form.
- The name of a binary molecular compound starts with the name of the element that has the lower group number. The name of the element that has the higher group number is last, and the ending is changed to *-ide*. Prefixes are used to indicate the numbers of atoms of the two elements. However, a prefix is not used for the first element if there is only one atom of this element.
- The formula for a binary molecular compound starts with the symbol for the element with the lower group number, followed by the symbol for the element with the higher group number. Subscripts indicate the numbers of atoms of the two elements in the compound.
- A structural formula shows how the atoms in a compound are attached to each other.

Review Questions

1. T/I Turn to page 64 and read the "dinner table" statements at the top of the page. Then answer the following questions.
   a. What do you think are the common names for sodium chloride, dihydrogen monoxide, and sodium hydrogen carbonate? Write the chemical formulas for these compounds.
   b. What do you think is the common name for sucrose?
   c. Identify each compound as an ionic compound or a molecular compound. Explain your reasoning.

2. K/U Explain why prefixes that indicate the numbers of atoms of the different elements are not needed in the names of ionic compounds.

3. K/U What is a polyatomic ion?

4. K/U What is the difference between a sulfate ion and a sulfite ion? How would you be able to determine the difference without looking up the names in a table?

5. T/I Write the name of each compound.
   a. Al_2O_3 **c.** Na_3P **e.** NH_4Cl **g.** $HNO_3(aq)$
   b. HgI_2 **d.** K_3PO_4 **f.** $LiClO_4$ **h.** $LiOH(aq)$

6. T/I Write the formula for each compound.
   a. zinc oxide **d.** magnesium iodide
   b. iron(II) sulfide **e.** cobalt(III) chloride
   c. potassium hypochlorite **f.** sodium cyanide

7. K/U Why must the name of a molecular compound include prefixes to indicate the numbers of atoms of the elements in the compound?

8. T/I The following six compounds contain nitrogen and oxygen: NO, NO_2, N_2O, N_2O_3, N_2O_4, and N_2O_5. Write the names of these compounds.

9. T/I Write the formula for each compound.
   a. phosphorus pentachloride
   b. difluorine monoxide
   c. sulfur trioxide
   d. silicon tetrabromide
   e. cobalt(II) hydroxide
   f. sulfur hexafluoride

10. T/I Write the name of each compound.
   a. CO **c.** CS_2 **e.** SiO_2 **g.** $Ba(OH)_2$
   b. BCl_3 **d.** CCl_4 **f.** PI_3 **h.** $H_3BO_3(s)$

11. K/U Explain why the name of C_3H_8 is not tricarbon octahydride.

12. T/I Draw Lewis structures for these compounds. From your Lewis structures draw structural formulas.
   a. NF_3 **b.** HCN **c.** $ClNO$

13. C In a group, discuss the advantages and disadvantages of using structural formulas.

14. T/I First draw a Lewis structure for each compound. Then, using your diagram, draw a structural formula.
   a. two carbon atoms bonded to each other, and two hydrogen atoms bonded to each carbon atom
   b. two carbon atoms bonded to each other, with three hydrogen atoms bonded to one carbon atom, and one hydrogen atom and one oxygen atom bonded to the second carbon atom