Topic 2.2

How can we understand, describe, and name chemical compounds?

Key Concepts

- Chemical compounds are formed from elements in the periodic table.
- Chemical compounds are represented using chemical names and chemical formulas.
- Reactive elements can become more stable when they form compounds.
- Chemical compounds are described as either ionic or molecular.
- Ionic compounds are named with the metal ion first and then the non-metal ion ending in "ide."
- Molecular compounds are named using numerical prefixes.

Key Skills

- Inquiry
- Literacy
- Research

Key Terms

chemical formula
ion

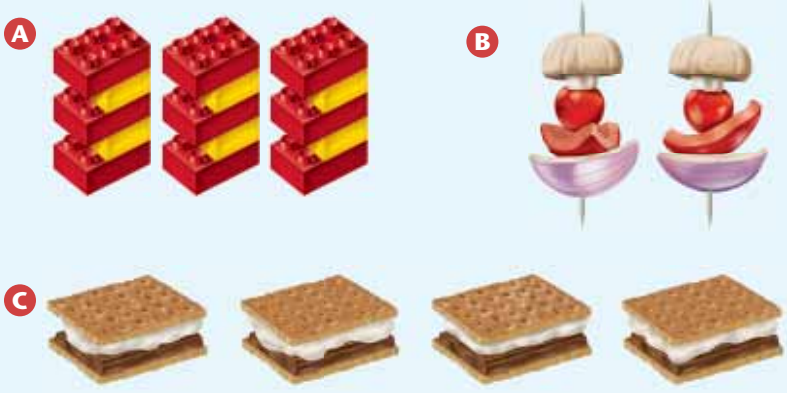
We use chemical reactions to purify water, to improve our food supply, to treat and prevent diseases, and to produce a wide range of products. Understanding chemical reactions helps you reduce the risks of using them. Part of understanding chemical reactions is knowing how to describe them. Just as you are known by a given name and perhaps a more familiar nickname, chemical compounds have an official name and a common name.

For example, many people add bleach to their laundry. Bleach is used to make clothes look whiter and brighter, as well as to disinfect them. However, there are different types of bleach, and each type uses a different chemical compound.

Starting Point Activity

The official chemical name for a chemical compound is based on the atoms that make up the compound. For instance, the compound sodium chloride is made up of atoms of sodium and atoms of chlorine.

1. Examine items A, B, and C. Pretend that each is a compound.
2. With a partner, create a name for each of them.
3. Use your experience of naming these three compounds to develop a set of rules that you could use to name other compounds.
4. Share and discuss your names and rules with the rest of the class.



For laundry, people use either "chlorine bleach" or "oxygen bleach." But these are common names, too! The official name of the compound used in "chlorine bleach" is sodium hypochlorite. The official name of the compound used in "oxygen bleach" is hydrogen peroxide.

Coming up with and learning how to recognize official names for more than 10^{200} (that's a 1 with 200 zeroes after it) compounds may seem like an impossible task. But there are rules that make this task simpler than you might think.

Chemical compounds are formed from elements in the periodic table.

▼ **Figure 2.6** This is a simple outline of the periodic table. The periodic table records information about the atomic structure and properties of the elements. (Also see the more complete periodic table on page 450.)

The first step to understand how scientists describe compounds is to understand how compounds are formed. All compounds are formed from two or more elements. **Figure 2.6** shows a simple outline of the period table.

The periodic table organizes all the elements in rows and columns. Each element has its own place in the periodic table, based on its properties and its atomic structure. Atomic structure refers to the numbers of electrons, protons, and neutrons that an atom of an element has.

Period 1	H																He
Period 2	Li	Be											B	C	N	O	F	Ne
Period 3	Na	Mg											Al	Si	P	S	Cl	Ar
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Period 6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Periods
Each row in the periodic table is called a *period*. The period number represents the number of electron shells in the atoms of an element.

Families
Each column in the periodic table is called a group or family. All the elements in a group have the same number of electrons in their outer electron shell. They also have similar chemical and physical properties.

Metals
The elements left of the staircase (blue) are metals. All metals except mercury are malleable, shiny, conduct heat and electric current, and are solids at room temperature.

Group 1 Metals
The Group 1 metals are also called alkali metals. They have only one electron in their outer electron shell. This makes them very reactive. In fact, the alkali metals in Group 1 are the most reactive metals. Their reactivity increases as you go down the group. The most reactive Group 1 metal is cesium (Cs).

Non-metals
The elements on the right (yellow) are non-metals. Non-metals are not malleable, do not conduct heat or electric current, and can be solids, liquids, or gases at room temperature.

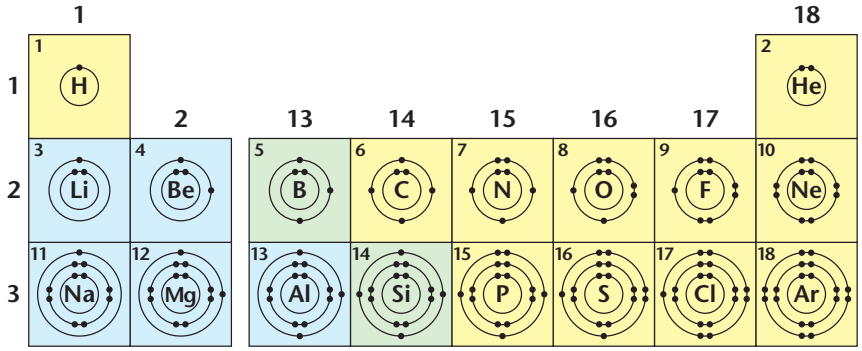
Group 17 Non-metals
The Group 17 non-metals are also called halogens. Their outermost electron shell is one electron short of being full. This makes the halogens very reactive. In fact, the halogens are the most reactive non-metals. Their reactivity decreases as you go down the group. The most reactive Group 17 non-metal is fluorine (F).

Group 18
The Group 18 elements are all gases. They have a full outer electron shell (eight electrons), which makes them unreactive. They are called the "noble gases" or "inert gases" because they do not react with other elements.

Period 1
There are only two elements in Period 1. Only two electrons will fit in their single electron shell. Helium is a noble gas because its one and only electron shell is full.

Hydrogen
Hydrogen is unique because it has only one electron. It can behave like the Group 1 metals, since it has only one electron in its outer shell. It can also behave like the Group 17 non-metals, since it needs only one electron to complete its outer shell. Some periodic tables put hydrogen in both groups.

Figure 2.7 focuses on the first 18 elements in the periodic table. Look closely at the number of electrons in the outermost electron shell of each element shown. The closer to a full electron shell that an atom has, the more reactive it is. The word *reactive* refers to how likely it is that an atom will take part in a chemical reaction and form a compound. If atoms are more reactive, they are more likely to take part in a chemical reaction. If atoms are less reactive, they are less likely to take part in a chemical reaction. The atoms of the elements in the last column, Group 18, are not reactive at all. That's because the elements in Group 18 have a full outer electron shell.



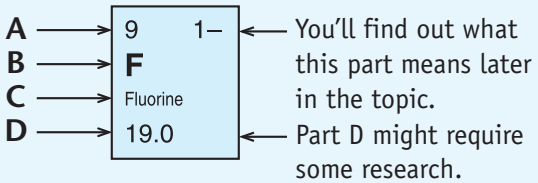
◀ **Figure 2.7** Each cell in the periodic table holds one element. The first 18 elements in the periodic table are shown here, along with their chemical symbol and the electrons in their electron shells.

Inquiry Focus

Activity 2.3

ELECTRONS AND PROTONS OF ELEMENTS

1. Look at this cell from the periodic table, which shows the element fluorine. Four parts are labelled A, B, C, and D. In your notebook, identify what each of the labels is.



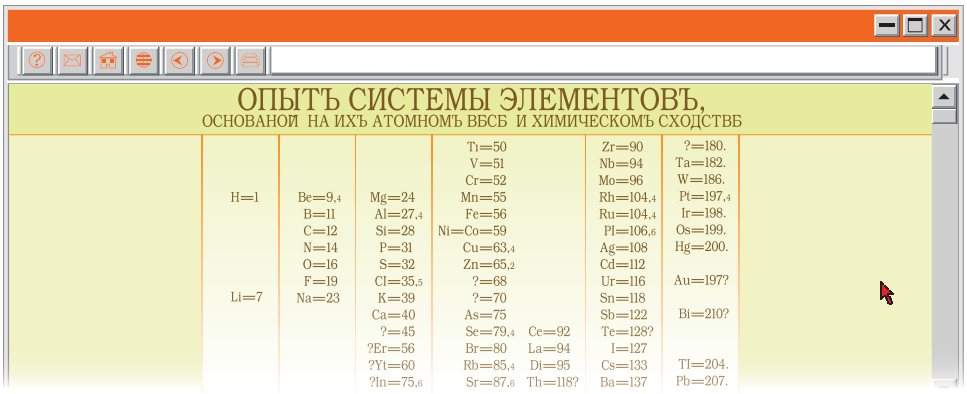
2. Draw the following cells from the periodic table: hydrogen, sodium, magnesium, oxygen, chlorine, and neon. Include labels for the four parts as in question 1.
3. State the number of protons in the nucleus of each of the elements in question 2.

LEARNING CHECK

1. Draw a simple outline of the periodic table. Use shading to identify where the metals and the non-metals are.
2. Name the group of elements that is not reactive. What feature makes the elements in this group not reactive?
3. Name the element in each pair that is more reactive, and explain how you know.
   a) K and Na **b)** F and Cl **c)** Na and Mg **d)** S and Cl
4. Using **Figure 2.7** as a guide, sketch the cells for the elements potassium and calcium. Your sketch must show the chemical symbol and the electron shells with their electrons.

Chemical compounds are represented using chemical names and chemical formulas.

In 1919, a group of chemistry organizations from around the world came together to form the International Union of Pure and Applied Chemistry (IUPAC). The chemists in IUPAC agreed on a set of chemical symbols that are used in the periodic table and in chemical formulas all over the world. As you can see in **Figure 2.8,** chemistry students everywhere in the world learn the same symbols rather than symbols based on their own alphabet and language.



▶ **Figure 2.8** Chemical symbols are an international language used by all chemists and students of chemistry, everywhere in the world.

chemical formula: a group of letters and subscript numbers that represent the make-up of a chemical compound

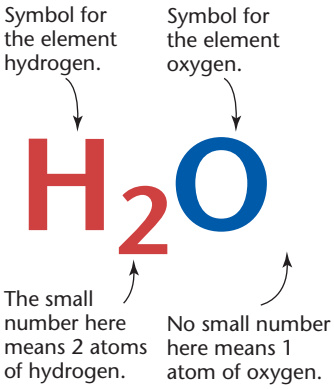
Chemical Formulas

We use short forms to simplify how and what we communicate. You already know that chemical symbols are the short forms that are used to represent the elements. There are also short forms that are used to represent the make-up of chemical compounds. The short form for a chemical compound is called a **chemical formula.**

Chemical formulas are made up of letters and subscript numbers.

- The *letters* are the chemical symbols. They tell you which elements are in the compound.
- The *subscript numbers* tell you how many atoms of these elements are in the compound.

Using a periodic table, you can determine which elements and how many atoms of each of these elements make up a compound. For example, the chemical formula for water is H_2O. As you can see in **Figure 2.9,** the chemical formula for water tells you that the compound is made up of the elements hydrogen (symbol H) and oxygen (symbol O). The subscript$_2$ beside the symbol H tells you that there are two hydrogen atoms for every one oxygen atom in the compound. Why doesn't the oxygen (symbol O) have a subscript$_1$ beside it? When there is only one atom of an element in a compound, you don't use a subscript$_1$ beside the symbol. The $_1$ is understood.



▲ **Figure 2.9** The chemical formula for the compound water, H_2O, tells you that there are two atoms of hydrogen (H) for every one atom of oxygen (O).

Literacy Focus

Activity 2.4

INTERPRETING CHEMICAL FORMULAS

1. Copy this table into your notebook, or use the table that your teacher gives you.
2. Follow the example in the first row to record the number of atoms of each element in the compounds.

The Chemical Formulas of Common Compounds

Name of Compound	Examples of Common Uses	Chemical Formula	Number of Atoms of Each Element
calcium carbonate	chalk for writing on chalkboard	$CaCO_3$	• 1 atom calcium (Ca) • 1 atom carbon (C) • 3 atoms oxygen (O)
sodium phosphate	heavy-duty cleaner	Na_3PO_4	
magnesium chloride	de-icer for roads	$MgCl_2$	
monosodium glutamate (MSG)	flavour-enhancer for foods	$NaC_5H_8NO_4$	
hydrogen peroxide	bleach and disinfectant	H_2O_2	
glucose	sweetener (glucose is a simple sugar)	$C_6H_{12}O_6$	
carbon dioxide	addition of fizz to pop	CO_2	
freon-12	refrigerator coolant (now banned because it harms the ozone layer)	CCl_2F_2	
HFC-32 (difluoromethane)	refrigerator coolant (now used because it does not harm the ozone layer)	CH_2F_2	

LEARNING CHECK

1. **a)** What does the subscript in a chemical formula indicate?
   b) What does having no subscript mean?
2. For the compound ammonia, NH_3, how many nitrogen atoms are there, and how many hydrogen atoms are there in each molecule?
3. Write the chemical formula for a compound that is made of one atom of carbon (C) and four atoms of hydrogen (H).
4. Write the chemical formula for a compound that has two atoms of nitrogen and four atoms of oxygen.

Reactive elements can become more stable when they form compounds.

You may have noticed patterns in chemical formulas. For example, some elements tend to form compounds with each other. Some elements appear in compounds more often than other elements. Some elements—the noble gases in Group 18—never appear in compounds. These patterns exist because of the atomic structure of the elements.

When elements form compounds, they become more stable. As you have learned, the noble gases rarely form compounds because they already have a stable electron-shell structure—their outer electron shell is full. All the other elements achieve this full, stable electron-shell structure in one of three ways:

1. Metals lose electrons to form positive ions.
2. Non-metals gain electrons to form negative ions.
3. Non-metals share electrons.

ion: an atom or a group of atoms that has an electrical charge, either positive or negative

The term **ion** refers to an atom that has a positive electrical charge or a negative electrical charge. **Table 2.1** summarizes the three ways that elements can achieve a stable electron-shell structure.

Inquiry Focus

Activity 2.5

BUILDING IONS

In this activity, you will use common materials to make models of atoms and ions.

What You Need

- variety of materials to represent nuclei and electrons

What To Do

1. Choose one element from Group 1, 2, 16, or 17.
2. Build a model of an atom of the element you chose. Use **Figure 2.17** on page 121 and the periodic table on page 450 for reference.
3. Sketch and name the atom.
4. Add or remove electrons as necessary to your atom to form an ion with a stable electron-shell structure.
5. Sketch and name the ion.

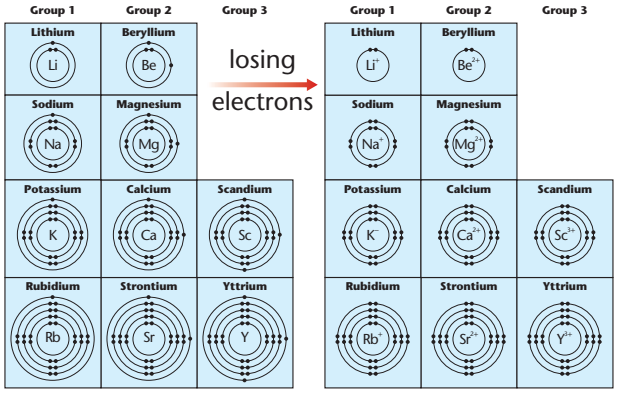
What Did You Find Out?

1. Compare your model of an ion with your classmates' models.
   (a) What do all the models have in common?
   (b) How are the models different? Explain.
2. How does your model of an ion compare with the model of an atom you built in step 2?

Table 2.1 The Three Ways That Elements Become Stable

1. Metals lose electrons to form positive ions.

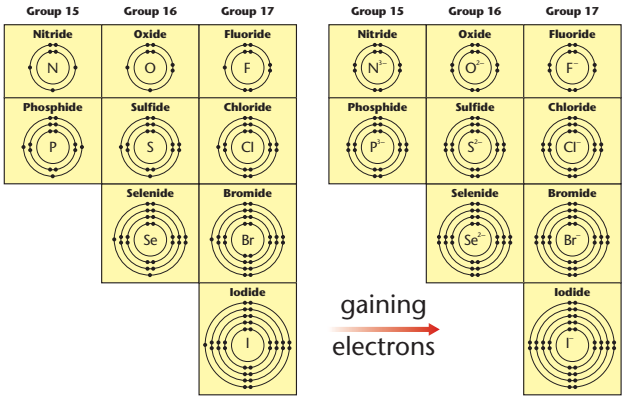
The charge on the Group 1 metal ions is +1 because they have lost one electron. The Group 2 metal ions have a charge of +2, and the Group 3 metal ions have a charge of +3.



Metal atoms can lose electrons to become stable. Because they have lost electrons, which have a negative charge, the charge on metal ions is positive. All metal ions have a stable electron-shell structure.

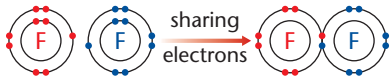
2. Non-metals gain electrons to form negative ions.

The charge on the Group 17 non-metal ions is –1 because they have gained one electron. The Group 16 non-metal ions have a charge of –2, and the Group 15 non-metal ions have a charge of –3.



Non-metal atoms can gain electrons to become stable. Because they have gained electrons, which have a negative charge, the charge on metal ions is negative. Notice that the name of a negative ion ends in "ide." All non-metal ions have a stable electron-shell structure.

3. Non-metals share electrons.



Non-metal atoms can also share electrons with other non-metal atoms to become stable. Their electron shells overlap. Since electrons have not been lost or gained, there is no charge on the atoms when electrons are shared.

LEARNING CHECK

1. Helium, like other noble gases, has a full, and therefore stable, outermost electron shell structure. How many electrons are in helium's outermost shell? What about the other noble gas elements? Why is there a difference?
2. How can metal elements achieve a stable electron-shell structure like those of the noble gases?
3. How can non-metal elements achieve a stable electron-shell structure like that of the noble gases?

Chemical compounds are described as either ionic or molecular.

Compounds can be divided into two main types, based on the differences in their properties. These two types are called ionic compounds and molecular compounds. The differences in their properties are due to the types of elements from which they are made.

Ionic Compounds

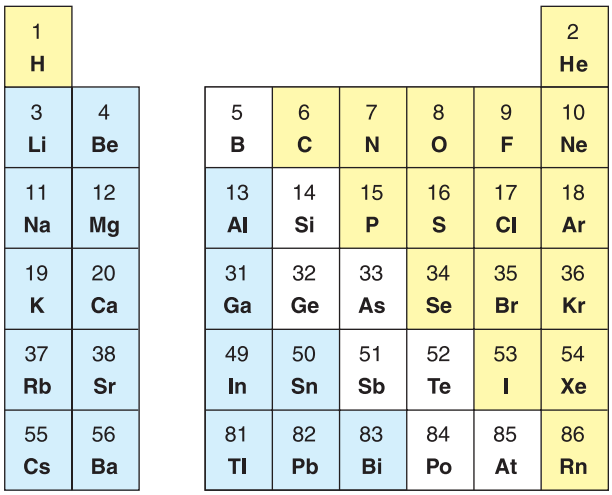
Metal ions (formed from metals on the left side of the periodic table) are positively charged, and non-metal ions (formed from non-metals on the right side of the periodic table) are negatively charged. Ionic compounds form because the positively charged metal ions attract the negatively charged non-metal ions.

Table 2.2 lists some examples of common ionic compounds. Ionic compounds have the following properties:

- They are solids at room temperature.
- They have a very high melting point.
- They conduct electricity when they are melted or dissolved in water.

Table 2.2 Examples of Ionic Compounds and Their Uses

Chemical Formula	Chemical Name (common name, if there is one)	Common Use
$NaCl$	sodium chloride (table salt)	seasoning for food
$CaCl_2$	calcium chloride (road salt)	de-icer for roads in the winter
CaO	calcium oxide (lime)	plaster
MgO	magnesium oxide (magnesia)	laxative
$CuBr_2$	copper(II) bromide	lasers and photographic processing



Molecular Compounds

Non-metal atoms can share electrons with other non-metal atoms including hydrogen. This is how molecular compounds are formed.

Table 2.3 lists some examples of common molecular compounds. Molecular compounds have the following properties:

- They may be solids, liquids, or gases at room temperature.
- They have lower melting points than ionic compounds.
- They do not conduct electric current when they are melted or dissolved in water, except in the case of certain acids.

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Table 2.3 Examples of Molecular Compounds and Their Uses

Chemical Formula	Chemical Name (common name, if there is one)	Common Use
CH_4	methane	heating
CO	carbon monoxide	production of acetic acid
$C_{12}H_{22}O_{11}$	sucrose (table sugar)	sugar
CCl_4	carbon tetrachloride	dry cleaning fluid
CH_3OH	methanol	windshield washer fluid

Literacy Focus

Activity 2.6

IONIC OR MOLECULAR?

1. Make a table like the one below to record your answers.
2. Identify the types of atoms in each compound. Then state whether each compound is ionic or molecular. Use the periodic table to help you. (You do not have to know the names of these compounds or their properties to do this.)

Chemical Formula	Types (metal or non-metal)	Ionic or molecular	Chemical Formula	Types (metal or non-metal)	Ionic or molecular
$MgBr_2$			SiF_4		
PH_3			Ag_3P		
P_4O_{10}			O_2F_2		
NaI			C_8H_{18}		

LEARNING CHECK

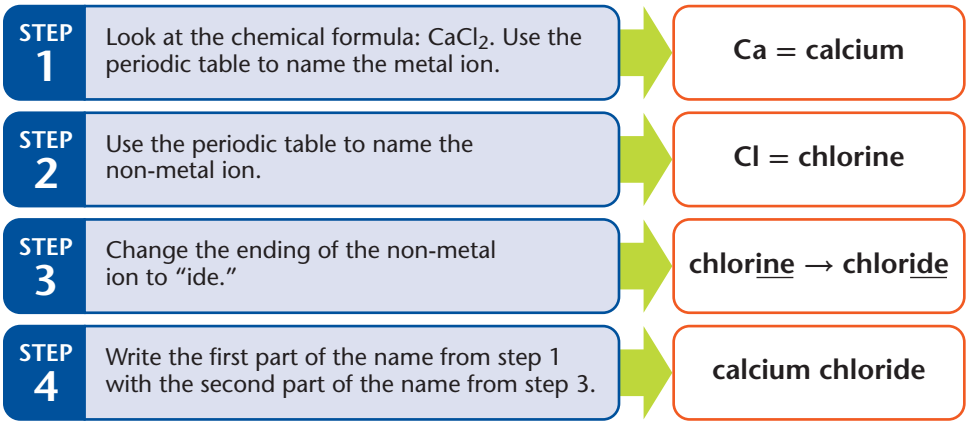
1. What type of elements combine to form ionic compounds?
2. What type of elements combine to form molecular compounds?

Ionic compounds are named with the metal ion first, followed by the non-metal ion ending in "ide."

Sometimes you are given the chemical formula of an ionic compound, and you are asked to name it. Sometimes you are given the name of an ionic compound, and you are asked to write its chemical formula. You will learn both of these skills here.

Naming a Simple Ionic Compound from Its Chemical Formula

An ionic compound has a two-part name. The first part of the name is the name of the metal ion. The metal ion has a positive charge. The second part of the name is the name of the non-metal ion, but it's changed so that it ends with "ide." The non-metal ion has a negative charge. Use **Figure 2.10** to learn how to name an ionic compound if you are given its chemical formula.



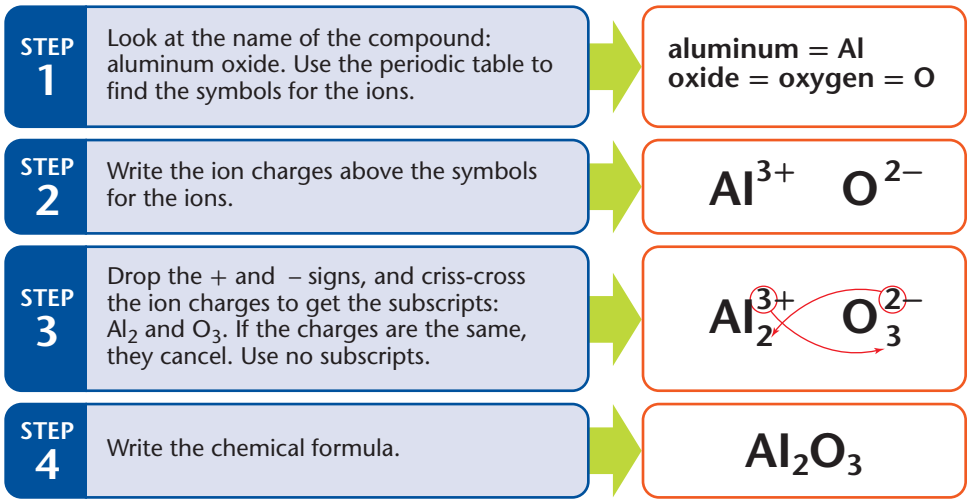
▲ **Figure 2.10** Follow these four steps to name an ionic compound from its chemical formula. Calcium chloride, $CaCl_2$, is used as an example.

Writing the Chemical Formula of a Simple Ionic Compound from Its Name

Figure 2.11 shows how to write the chemical formula of an ionic compound if you are given its name. You will need a periodic table with the ion charges for the elements in the upper right-hand corner of each cell. Turn to page 450, and make sure that you can find the ion charges for the elements before you continue. **Table 2.4** shows the names of some of the common non-metal ions.

Table 2.4 Common Non-metal Ions

Element Name	Element Symbol	Ion Symbol	Ion Name
nitrogen	N	N^{3-}	nitride
oxygen	O	O^{2-}	oxide
fluorine	F	F^{-}	fluoride
phosphorus	P	P^{3-}	phosphide
sulfur	S	S^{2-}	sulfide
chlorine	Cl	Cl^{-}	chloride
selenium	Se	Se^{2-}	selenide
bromine	Br	Br^{-}	bromide
iodine	I	I^{-}	iodide



◀ **Figure 2.11** Follow these four steps to write the chemical formula of a compound from its name. Aluminum oxide, Al_2O_3, is used as an example.

LEARNING CHECK

1. Explain how ionic compounds are named.
2. Name these ionic compounds.
   a) NaBr **b)** LiF **c)** $MgBr_2$ **d)** AlI_3 **e)** K_2S
3. How do you know how many of each type of element there are in an ionic compound?
4. Write the chemical formula for these ionic compounds.
   a) cesium fluoride
   b) strontium chloride
   c) barium oxide
   (Hint: The charges are the same)
   d) potassium phosphide
   e) aluminum nitride

ACTIVITY LINK
Activity 2.8, on page 136

Molecular compounds are named using numerical prefixes.

The rules for naming molecular compounds are different from the rules for naming ionic compounds. Why? There is only one way that two specific ions can react to form an ionic compound. But there are many ways that atoms of two non-metal elements can react to form a molecular compound. For example, **Table 2.5** shows six different molecular compounds that contain only nitrogen and oxygen.

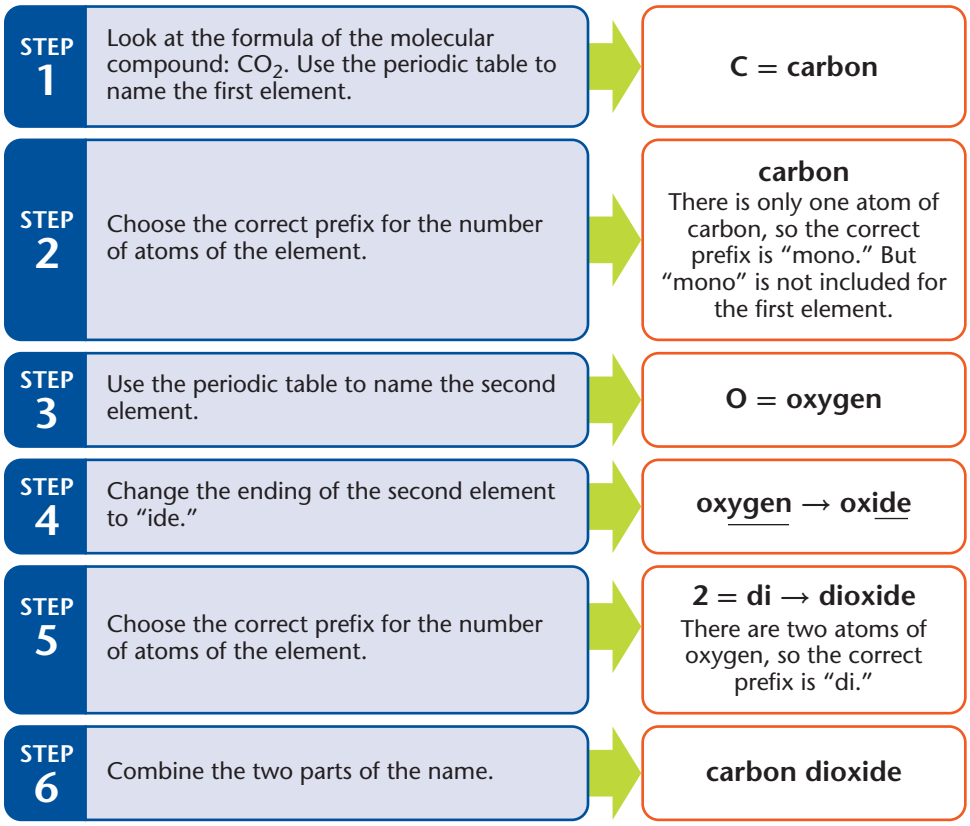
Table 2.5 Six Molecular Compounds That Contain Nitrogen and Oxygen

Chemical Formula	IUPAC Name	What It Is
NO	nitrogen monoxide	pollutant from car exhaust
N_2O	dinitrogen monoxide	used by dentists (laughing gas)
NO_2	nitrogen dioxide	used to make nitric acid
N_2O_3	dinitrogen trioxide	deep blue liquid
N_2O_4	dinitrogen tetroxide	used in rocket fuel
N_2O_5	dinitrogen pentoxide	dissolves in water to form nitric acid

Naming a Molecular Compound from Its Chemical Formula

Molecular compounds have a two-part name. Both parts of the name are taken from the names of non-metals. To decide which non-metal atom to name first, find the one with the lower group number on the periodic table. For example, if the compound contained carbon and oxygen, carbon would be first because it is in Group 14, which has a lower group number than oxygen's group, Group 16. Even if the non-metals are in different periods, the rule is the same. If the compound contained phosphorus and fluorine, for example, phosphorus would be named first because it is in Group 15, which has a lower group number than fluorine's group, Group 17. The fact that phosphorus and fluorine are in different periods on the periodic table does not affect the naming. When you have found the non-metal to name first, use that element's name as the first part of the compound name. The second part of the name is taken from the name of the second non-metal. However, you have to change the ending of the name to "ide."

Because elements can combine in more than one way, a numerical (number-indicating) prefix is used to tell how many of each type of element are in the compound. Look at the examples of numerical prefixes in **Table 2.6**. Then use **Figure 2.12** to see how to name a molecular compound from its formula.



▲ **Figure 2.12** Follow these steps to write the name of a molecular compound from its chemical formula. Carbon dioxide, CO_2, is used as an example.

It is important to note that these rules for naming do not apply to a large group of molecular compounds called organic compounds. Organic compounds consist of mostly carbon and hydrogen. They might also contain oxygen, sulfur, and a few other elements. Organic compounds have a naming system of their own. If you take more chemistry courses, you will learn about organic compounds.

Table 2.6 Numerical Prefixes Used for Molecular Compounds

Numerical Prefix	Number It Represents
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8

Note: The prefix "mono" is used only for the second element in the name.

Note: When a prefix ending with a vowel ("o" or "a") is used with oxygen, the vowel is dropped. For example, use "monoxide" not "monooxide" and "tetroxide" not "tetraoxide."

LEARNING CHECK

1. Explain how molecular compounds are named.
2. Name these molecular compounds:
   a) SO_2 **b)** SO_3 **c)** CCl_4 **d)** PCl_5 **e)** CO

continued on the next page . . .

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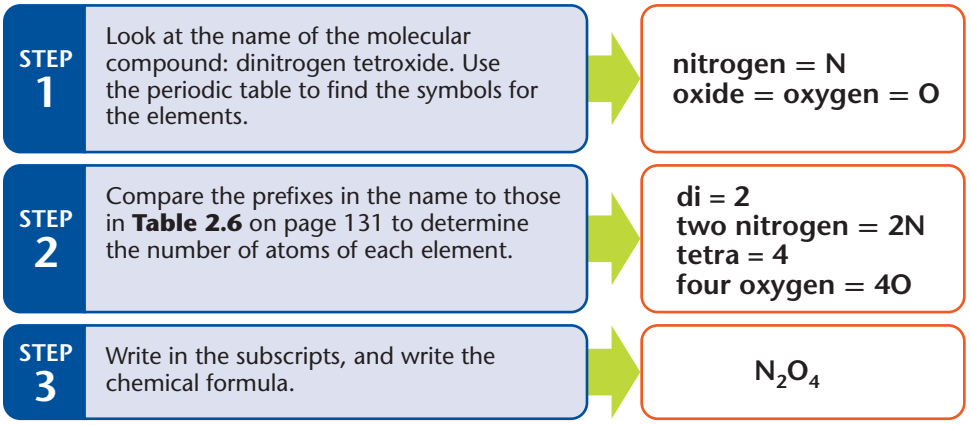
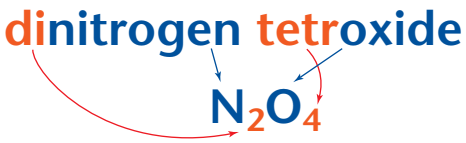
Writing the Chemical Formula of a Molecular Compound from Its Name

Now that you have learned how to write names for molecular compounds from their formulas, you can probably figure out how to write the formulas from the names. First, you look at the name to find the elements in the compound. Then, if you do not remember the symbols for those elements, you refer to a periodic table, such as the one on page 450, to find the symbols. Next, you look at the prefixes to determine the number of atoms of each element in the compound. If you do not remember the numbers represented by those prefixes, go to **Table 2.6** to find the number. Finally, you write the number of atoms of each element as a subscript on the symbol. **Figure 2.13** summarizes this process and provides an example that shows how to write the chemical formula of a molecular compound from its name.





▶ **Figure 2.13** Follow these steps to write the chemical formula of a molecular compound from its name. Dinitrogen tetroxide, N_2O_4, is used as an example.

LEARNING CHECK

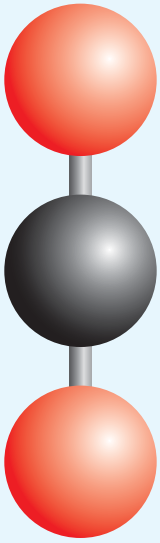
1. What feature of the name of a molecular compound tells you the number of atoms of each element in the compound?
2. Write the chemical formula for the following molecular compounds.
   - **a)** sulfur difluoride
   - **b)** nitrogen monoxide
   - **c)** disulfur trioxide
   - **d)** disulfur difluoride
   - **e)** silicon tetrachloride
   - **f)** diphosphorus pentoxide
   - **g)** carbon disulfide
   - **h)** carbon tetraiodide
   - **i)** dinitrogen tetrasulfide

Inquiry focus

Activity 2.7

BUILDING MODELS OF MOLECULAR COMPOUNDS

In this activity, you will build and name a number of molecular compounds.



What You Need

- materials to build molecular compounds

What to Do

1. Make a table in your notebook like the one below. Leave space in the last column to sketch your models.
2. Fill in the first four columns of the table. Refer to the information on pages 130 to 132 to help you.
3. Using the information in the first four columns of your table, build a model for each molecule. Hint: Start with the element in bold type in the table, and add the other elements around it.
4. Sketch your models in the fifth column of the table.

Building and Naming Molecular Compounds

Element 1 and Number	Element 2 and Number	Chemical Formula	Chemical Name	Sketch of Model
1 **C**	2 S			
		CO		
			nitrogen dioxide	
1 **B**	3 Cl			
		N_2O		
			phosphorus trifluoride	

continued on the next page . . .

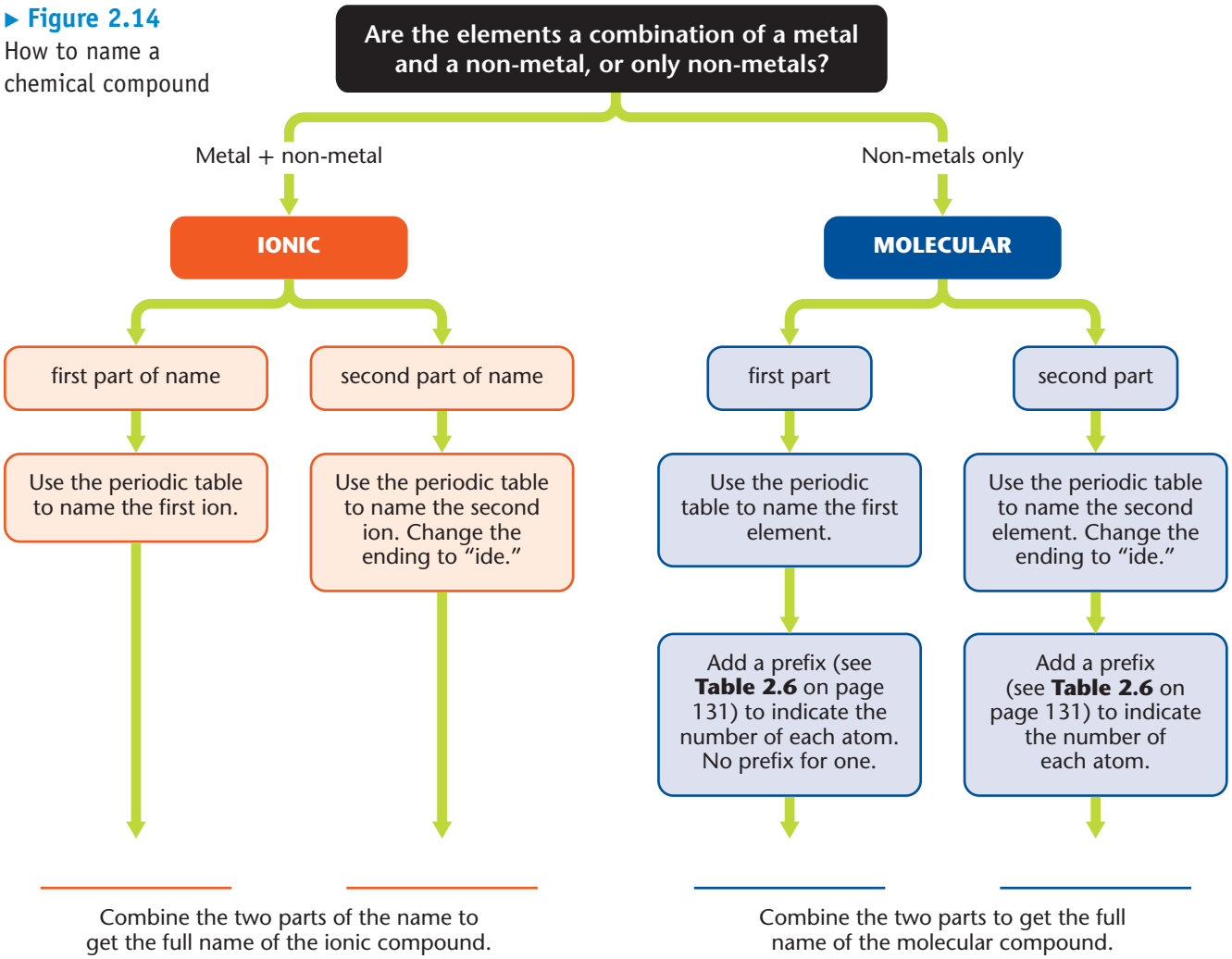
... continued from previous page

A flowchart can be used to simplify the process of naming chemical compounds.

Go to **scienceontario** to find out more

The fist step in naming or determining the formula of a compound is deciding whether the compound is an ionic compound or a molecular compound. Use the flowchart in **Figure 2.14** to help you name chemical compounds. Use the flowchart in **Figure 2.15** on the next page to help you write chemical formulas.

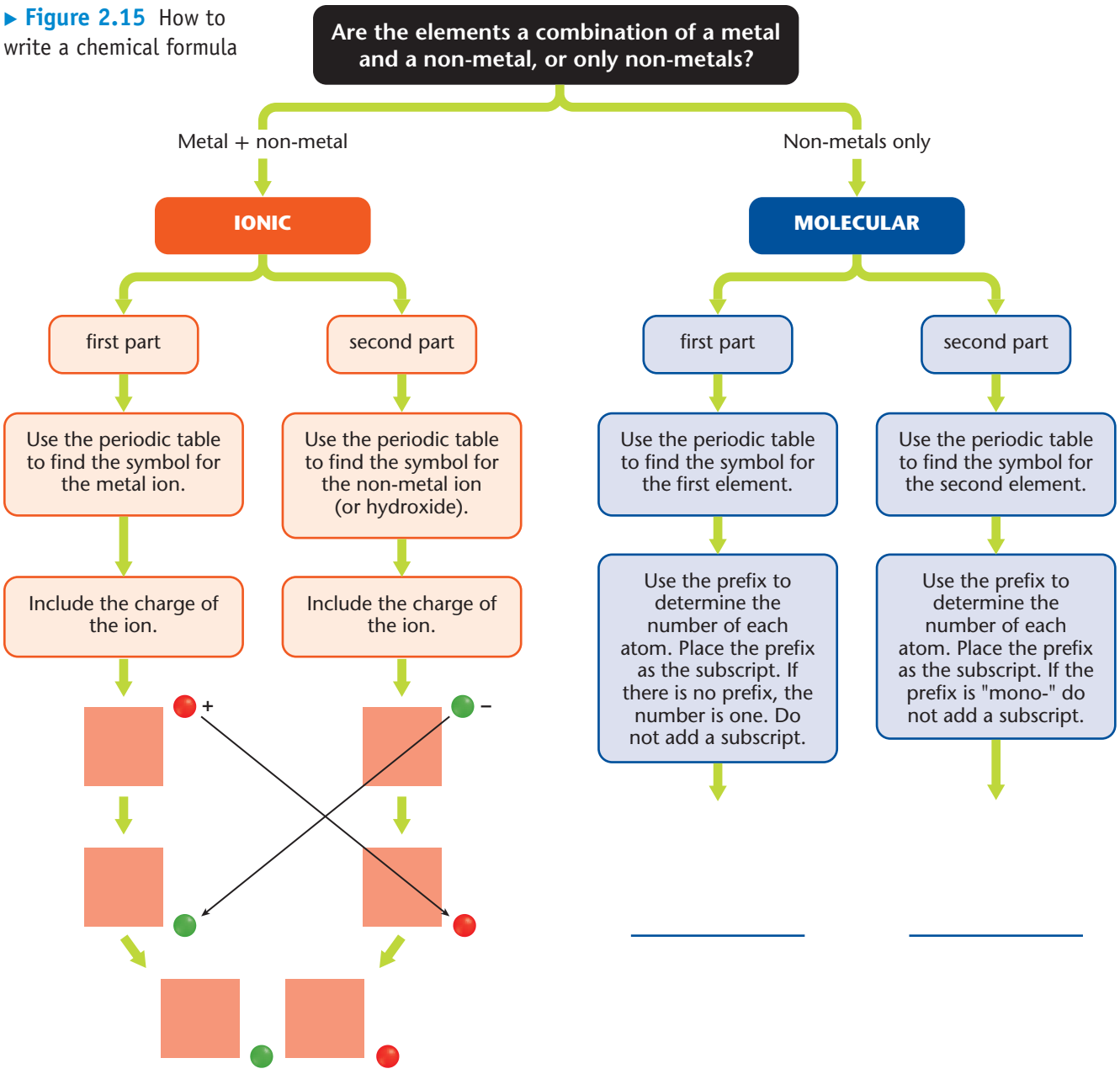
▶ Figure 2.14
How to name a chemical compound



LEARNING CHECK

1. What is the first step in naming a compound from its chemical formula?
2. Identify the following compounds as ionic or molecular and name the compounds.
   a) KCl **b)** As_2O_5 **c)** $MgBr_2$ **d)** PCl_3 **e)** SeF_6 **f)** Mg_3P_2

▶ **Figure 2.15** How to write a chemical formula



LEARNING CHECK

1. What is the first step in writing the chemical formula from a name?
2. Identify the following compounds as ionic or molecular and write the chemical formula.
   - **a)** calcium oxide
   - **b)** dinitrogen triiodide
   - **c)** sodium phosphide
   - **d)** iodine trichloride
   - **e)** phosphorus pentabromide
   - **f)** aluminum phosphide

Inquiry Focus

Activity 2.8

MODELLING IONIC COMPOUNDS

In this activity, you will use different shapes to represent metal ions and non-metal ions. These shapes can be combined in a way that closely matches the way that real ions combine during a chemical reaction. The patterns that you will discover here will help you write the names and formulas of ionic compounds.

Safety

What You Need

- set of shapes in one colour, representing different metal (positive) ions
- set of shapes in a different colour, representing different non-metal (negative) ions
- scissors

What To Do

1. Make a table like the one below to record your answers.

Building and Naming Ionic Compounds

Metal Ion (Positive)	Non-metal Ion (Negative)	Compound Name	Compound Formula
K^+	I^-		
Al^{3+}	P^{3-}		
Mg^{2+}	F^-		
Na^+	O^{2-}		
Ba^{2+}	Cl^-		
Ga^{3+}	F^-		
Ca^{2+}	N^{3-}		

2. Work with a partner to build the ionic compounds.
3. Cut out the shapes on the photocopied sheets that your teacher has given you. Keep these facts in mind:
   - Each shape represents a single metal or non-metal ion.
   - Each metal (positive) ion looks like a rectangle with a piece cut out. The cut-out part is called a hole.
   - Each non-metal (negative) ion looks like a rectangle with a piece attached. The extra piece is called a peg.
4. For each ionic compound, you will need one kind of positive ion and one kind of negative ion. You must follow these rules:
   - Every hole must be filled with a peg, and every peg must be in a hole. Keep adding ions until this happens.
   - The positive and negative ions must alternate as much as possible throughout the compound.

What Did You Find Out?

1. When the ionic compound model is complete, how many positive charges (holes) do you have, compared with how many negative charges (pegs) you have?
2. An unknown compound that includes the bromide ion (Br^-) has the chemical formula XBr_2. Use your models to find the charge on the ion that is represented by X in this chemical formula.

Research Focus

Activity 2.9

KITCHEN CHEMISTRY

Natural foods (such as apples) and processed foods (such as fruit leather) contain chemicals. However, only processed foods are labelled to show their chemical make-up. The ingredients on a label are listed in order of decreasing amount. For example, the label for table salt might read "salt (sodium chloride), calcium silicate, potassium iodide." This means that there is less potassium iodide in the product than any other ingredient. Sodium chloride is the main ingredient.

What To Do

1. Select one processed food product in your home, and answer the following questions.
   - **a)** Name the product.
   - **b)** List the ingredients in the same order that they are listed on the label.
2. Make a table like the one below. Select any three of the ingredients for which you can provide the information required by the table. Then complete your table. You may need to use the Internet or other resources to find the chemical formulas.
3. Research the properties of one of the ingredients in your table. Explain why this chemical substance is added to the processed food.

The Ingredients in a Processed Food

	Ingredient 1	Ingredient 2	Ingredient 3
Name			
Formula			
Elements It Contains			
Ionic or Molecular?			

Skills

initiating and planning

✓ **performing and recording**

✓ **analyzing and interpreting**

✓ **communicating**

Safety

- Do NOT taste any samples.

What You Need

- 250 mL beaker
- scoop
- stirring rod
- conductivity tester
- distilled water
- Epsom salts
- isopropyl alcohol (rubbing alcohol)
- washing soda
- sugar
- vegetable oil

Ionic or Molecular?

Like detectives searching for clues, chemists classify substances by matching their observations against theories about ionic and molecular compounds. In this activity, you will determine whether some common household substances are ionic or molecular by observing their properties.

What To Do

1. Make a table like the one below to record your data.

Ionic or Molecular?

Substance	State at Room Temperature (Is it a solid, liquid, or gas?)	Solubility in Water (Does it dissolve?)	Conductivity as a Liquid or Dissolved in Water
distilled water		n/a	
Epsom salts			
rubbing alcohol			
washing soda			
sugar			
vegetable oil			

2. Examine each of the five substances. Record whether it is a solid, liquid, or gas at room temperature.
3. Add approximately 100 mL of distilled water to a beaker. Use the conductivity tester, as demonstrated by your teacher, to determine whether the distilled water conducts electricity. Record your data.
4. Use the scoop to add a small amount of Epsom salts to the water. Stir with the stirring rod to try to dissolve the Epsom salts. Record the solubility of the Epsom salts in water. (Do they dissolve?)
5. Use the conductivity tester to test the solution of Epsom salts and water. Record the conductivity of the Epsom salts. (Do they conduct electricity?)
6. Clean your beaker, stirring rod, and conductivity apparatus.
7. Repeat steps 4 to 6 for the remaining substances. If a substance is a liquid at room temperature, test the conductivity of the liquid, not when it is mixed with water. Record your data, and clean up when you are done.

What Did You Find Out?

1. Use the information on pages 126 and 127 to classify the substances as ionic or molecular compounds.

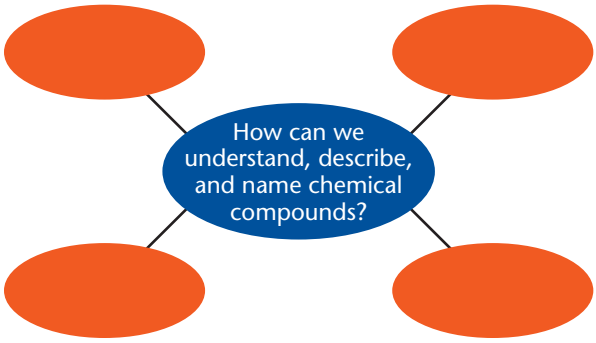
Topic 2.2 Review

Key Concept Summary

- Chemical compounds are formed from elements in the periodic table.
- Chemical compounds are represented using chemical names and chemical formulas.
- Reactive elements can become more stable when they form compounds.
- Chemical compounds are described as either ionic or molecular.
- Ionic compounds are named with the metal ion first, and then the non metal ion ending in "ide."
- Molecular compounds are named using numerical prefixes.

Review the Key Concepts

1. K/U Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. K/U **a)** Provide the name and symbol for a metallic element.

b) Which group of non-metals is the most reactive? Why?

c) Which metal is the most reactive? Why?

3. T/I Write the chemical formula for each of the following compounds given the number of each type of element present:

a) 2 atoms nitrogen, 2 atoms hydrogen

b) 1 atom calcium, 1 atom carbon, 3 atoms oxygen

c) 3 atoms calcium, 2 atoms phosphorus

d) 2 atoms sodium, 2 atoms sulfur, 3 atoms oxygen

4. T/I Classify the following compounds as ionic or molecular:

a) $MgCl_2$ **c)** $C_{25}H_{52}$ **e)** Ca_3N_2

b) $AlBr_3$ **d)** SiO_2

5. T/I For each of the following, state either the name or the chemical formula.

a) CsBr **d)** potassium chloride

b) BaO **e)** aluminum bromide

c) Ca_3P_2 **f)** potassium oxide

6. For each of the following, state either the name or the chemical formula.

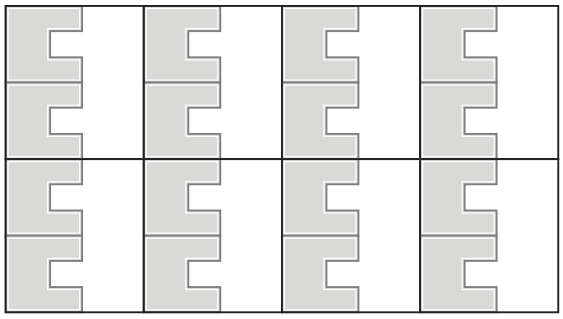
a) P_2O_5 **d)** dinitrogen tetrafluoride

b) CF_4 **e)** sulfur hexachloride

c) PH_3 **g)** sulfur dibromide

7. T/I Which of the following ionic compounds is represented in the diagram? Explain your answer.

a) NaCl **b)** Na_2O **c)** Na_3P



8. C Use the example calcium nitride to explain the steps in determining the chemical formula of a compound from its name.