6.2 Naming and Classifying the Elements

To learn more about the origins of the names of the elements, visit **www.science.nelson.com** GO

The names of the elements have varied origins. Some elements are named for special properties such as "light giving" (phosphorus) and "water forming" (hydrogen). Many are named to honour scientists (for example, einsteinium), countries (for example, germanium), or cities (for example, berkelium). Most of the ancient elements were given Latin names, such as plumbum for lead. This name later became the basis for the name of the repair people who often work on pipes that were originally made of lead—plumbers. GO

With over a hundred elements and many thousands of compounds to describe and discuss, scientists needed a symbolic system that could describe every element and compound precisely. The system that was developed, based on the names of the elements, is both elegant and simple.

Symbols

The Workplace Hazardous Materials Informatoin System (WHMIS) system is a good example of the power of symbols to communicate. When you see a WHMIS symbol, it can both change and guide your behaviour instantly. There are only a few WHMIS symbols, so remembering them is easy. (See the Skills Handbook for examples of WHMIS symbols.) For a system to describe every element and compound, many more symbols are needed.

In the early 1800s, Swedish chemist Jons Jakob Berzelius rose to the challenge. He started by suggesting a symbolic system to describe all the elements using the letters of either their common name or their Latin name. Examine the elements in Table 1, and see if you can recognize the rules he used to decide which letters are allowed, how many are permitted, and which should be capitalized.

Table 1 Some Elements and Their Symbols

Name	Symbol	Name	Symbol	Name	Symbol	Name	Symbol
aluminum	Al	chromium	Cr	indium	In	nobelium	No
antimony	Sb	cobalt	Co	iodine	I	oxygen	O
arsenic	As	copper	Cu	iron	Fe	palladium	Pd
barium	Ba	erbium	Er	krypton	Kr	phosphorus	P
beryllium	Be	europium	Eu	lead	Pb	platinum	Pt
bismuth	Bi	fluorine	F	lithium	Li	plutonium	Pu
boron	B	francium	Fr	manganese	Mn	polonium	Po
bromine	Br	gallium	Ga	magnesium	Mg	potassium	K
cadmium	Cd	germanium	Ge	mercury	Hg	radium	Ra
calcium	Ca	gold	Au	neon	Ne	radon	Rn
carbon	C	helium	He	nickel	Ni	scandium	Sc
chlorine	Cl	hydrogen	H	nitrogen	N	selenium	Se

Table 1 Some Elements and Their Symbols (continued)

Name	Symbol	Name	Symbol	Name	Symbol	Name	Symbol
silicon	Si	sulfur	S	titanium	Ti	ytterbium	Yb
silver	Ag	technetium	Tc	tungsten	W	yttrium	Y
sodium	Na	terbium	Tb	uranium	U	zinc	Zn
strontium	Sr	tin	Sn	xenon	Xe	zirconium	Zr

To give every element a unique symbol, Berzelius suggested the following:

- Every element is represented by the first letter of its name or by the first letter of its name and a second letter from its name. For the elements that were identified first, the letters were taken from their Latin names.
- When a first letter was previously used, a letter from the rest of the name is added; for example, C was used for carbon, so calcium became Ca, cobalt became Co, and chromium became Cr.
- The first letter is always capitalized and the second letter is always lower case.

LEARNING TIP

Explain to a partner the rules governing the chemical notations in Table 1. Did you find any symbols that did not follow the rules exactly?

Although having a symbol for every element was an accomplishment, Berzelius considered the second part of his symbolic system the most important. As chemists came to recognize many compounds that were previously thought to be mixtures, they discovered that the ratio or proportion of the elements in a compound is always small whole numbers. The identification of compounds not only required symbols for each element, but also symbols to show the proportion of the elements in each compound. Berzelius stated that every compound can be identified by a formula that shows the elements and their proportions in the compound.

You already know some of these formulas, such as H_2O for the compound water and CO_2 for the compound carbon dioxide (Figure 1). The formula for water tells you that there are two parts hydrogen and one part oxygen. The formula for carbon dioxide tells you that there is one part carbon and two parts oxygen. You will learn more about these formulas in Chapter 8.

(a) (b)

Figure 1 (a) The compound water is two parts hydrogen and one part oxygen. (b) The compound carbon dioxide is one part carbon and two parts oxygen.

Classifying the Elements

All elements are different from each other. The properties of any element are unique to this element and can therefore be used to identify it. Some elements, however, have similar chemical and physical properties. These elements are often grouped together. Grouping elements together according to their properties helps predict how they might react.

Metals, Non-Metals, and Metalloids

One common way to classify elements based on their physical and chemical properties is to group them as as metals, non-metals, or metalloids. Although you may be more familiar with metals, you will discover that there are a few non-metals and metalloids you have used and others you have heard about.

TRY THIS: Grouping Elements

Skill Focus: conducting, observing, recording, analyzing, evaluating, classifying

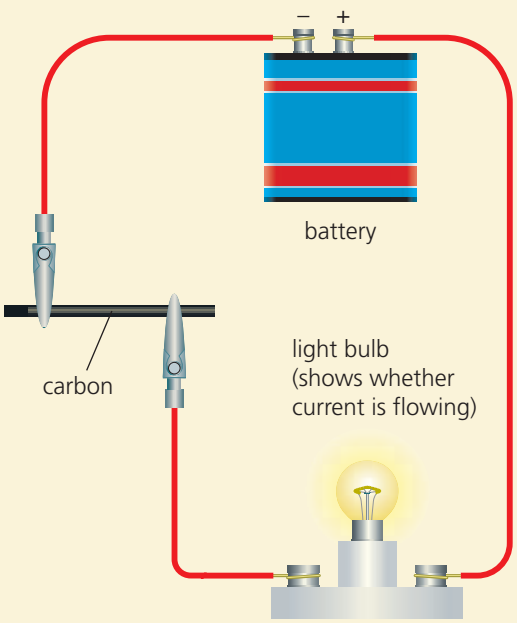

Figure 2

Materials: index cards; 3 connecting wires, battery, light bulb with base; samples of the elements carbon, tin, silicon, copper, zinc, magnesium, sulfur, aluminum

Elements can be grouped in many ways. In this activity, you will group some elements according to two properties.

1. Write the chemical symbol for each element at the top of a card, and the name of the element beneath.
2. Assemble the conductivity apparatus as shown in Figure 2. Place the connecting wires at opposite ends of each sample. If the bulb glows, the element can conduct electricity. Record your observations on the card.
3. Observe the lustre (shininess) of each element. Does the element reflect light? Record your observations on the card.

A. Which elements have the properties of lustre and electrical conductivity? Which elements do not have either of these two properties? Are there any elements that have one of the properties, but not the other? If so, which elements?

B. Generally, the elements that have lustre and conduct electricity are classified as metals. Which of the elements can be classified as metals? Which of the elements can be classified as non-metals?

Did You KNOW?

Precious Metals

Certain metals are considered to be precious—an element with high monetary value. Precious metals include gold, silver, platinum, and palladium. Today, these metals are generally used to make art, jewellery, and high-value coins for collectors. In the past, however, precious metals were used as currency.

Metals

Most of the elements discovered first were metals. Certainly much of the interest of the alchemists was to convert the common and inexpensive metals into gold. You may be surprised, however, to know that most of the elements known today are metals. Metals have a wide range of both chemical and physical properties, but they all share some important ones that make them metals. Most **metals** have the properties listed in Table 2.

Table 2 Properties of Metals

Property	Characteristic
lustre	shiny
malleability	malleable (can be formed or shaped)
ductility	ductile (can be stretched into wire)
conductivity	good conductors of heat and electricity
state	solid at room temperature (except mercury, which is liquid at room temperature)
density	usually denser than non-metals
reactivity	active metals react with acid, and very active metals react with water

Tungsten, iron, copper, nickel, lead, zinc, tin, magnesium, aluminum, mercury, and chromium are some of the elements that are classified as metals (Figure 3).

Non-Metals

The elements that do not have the characteristics of metals are usually classified as non-metals. Most **non-metals** typically have the properties listed in Table 3.

Table 3 Properties of Non-Metals

Property	Characteristic
lustre	dull appearance
malleability	likely to be brittle or shatter when struck
melting point and boiling point	usually lower melting and boiling points than metals
state	often gases at room temperature
conductivity	poor conductors of heat and electricity

LEARNING TIP

As you study Table 3, ask yourself, "Would non-metals make very good jewellery?" Explain your thinking to a partner.

Fluorine, phosphorus, chlorine, bromine, iodine, and sulfur are some of the elements that are classified as non-metals (Figure 3).

(a)

(b)

Figure 3 Metals, such as chromium (a), tend to be shiny and malleable, while non-metals, such as sulfur (b), tend to be dull and brittle.

Metalloids or Semi-Metals

A few elements do not fit exclusively into either group and are called **metalloids** (semi-metals or semiconductors). Silicon, germanium, arsenic, antimony, and tellurium exhibit some of the qualities of both metals and non-metals. For instance, silicon is shiny and a solid at room temperature (like a metal) but is a poor conductor of electricity and is brittle (like a non-metal) (Figure 4). Many of the metalloids are semiconductors of electricity, meaning that they have a partial ability to conduct electricity—from almost no ability to full conductivity. This property is useful in the electronics industry and has made the metalloids a very important group in today's world.

Figure 4 Silicon has qualities of both a metal and a non-metal.

6.2 CHECK YOUR Understanding

1. Look at Table 1 (pages 188–189). Match each element with its proper symbol.

Element	Symbol
mercury	W
arsenic	Pd
tin	Sn
potassium	Fr
francium	Fe
palladium	As
antimony	P
phosphorus	Hg
iron	K
tungsten	Sb

2. Look at Table 1 (pages 188–189). Make a list of at least five elements that are named after places.
3. Which elements do you think have symbols based on their Latin name? Why? Can you find at least five?
4. Use Table 1 (pages 188–189) to find the names of the elements with the symbols Tc, Co, Cu, Sc, Y, Ar, Ag, Pb, Pd, and Kr.
5. Summarize the rules for writing the symbols for the elements.
6. What two things does the formula of a compound tell us?
7. The formulas of some compounds are listed in Table 4. Copy the table into your notebook and complete the second column by writing the names of the two elements in each compound.

Table 4

Compound	Elements in the compound
ZnS	
H_2O	
NaCl	
CaS	
CH_4	
$CuCl_2$	
PbO_2	
K_2S	

8. One element in Table 1 on pages 188 and 189 does not have a Latin name, but its symbol is not taken from its name in the table. Which element is it?
9. Name three physical properties that you would expect to find in a metal.
10. Which metal is a liquid at room temperature?
11. Based on the differences between metals and non-metals, answer the following questions.
    (a) Does copper conduct heat well?
    (b) Does lead shine?
    (c) Does sulfur conduct electricity?
    (d) Is germanium a metalloid?
    (e) Is phosphorus malleable?
    (f) Is chlorine ductile?
12. Argenta is a town in British Columbia. What do you think might have been mined there? Can you think of a country that used the same root for its name?
13. Do you think that non-metals would make very good jewellery? Explain your thinking.
14. What evidence suggests that some elements are more rare than others?
15. Some elements were named for their physical or chemical properties. Unfortunately, for many of us, the Greek language was used for these properties. Which element might each of the following be?
    (a) water forming
    (b) light bearing
    (c) stench
16. If there were an award for having the most elements named after a location, it would certainly be won by a small village in Sweden called Ytterby. Four elements were named after this village. Can you find two of these elements? Can you find all four?
17. Suggest a name and a symbol that could be used if a new element were to be named after Canada. Now suggest a name and a symbol that could be used for an element named after you. (Remember that you cannot duplicate any existing symbols).