A Table of the Elements

6.1

Perhaps you have already seen the periodic table of elements in the science lab (Figure 1). The periodic table is a work of science—a compilation of years of inquiry and experimentation. It is also a work of beauty—a masterful joining of evidence and theory. As you learn more about the structure of matter, you will discover and appreciate the many layers of information that are stored in the periodic table.

1												13	14	15	16	17	18
H	2																He
Li	Be											B	C	N	O	F	Ne
Na	Mg	3	4	5	6	7	8	9	10	11	12	Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
				Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
				Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Figure 1 The periodic table of the elements

How does a substance qualify to occupy a spot on the periodic table? Note that the periodic table is a table of elements. An **element** is a pure substance that cannot be broken down into a simpler chemical substance by any physical or chemical means. Consider silver. You cannot carry out any chemical reactions or physical changes that will convert silver into anything chemically simpler. Pure silver is the simplest form of the element silver.

element a pure substance that cannot be broken down into a simpler chemical substance by any physical or chemical means

The element symbol Ag is used to represent silver on the periodic table. An **element symbol** is an abbreviation for a chemical element. Ag stands for argentum, which is the Latin word for silver. Some elements on the periodic table have abbreviations that are based on their Latin names.

element symbol an abbreviation for a chemical element

compound a pure substance composed of two or more different elements that are chemically joined

Now consider water. How can you tell if it is an element? Simple: if it is an element, it is on the periodic table. Conversely, anything that is not on the periodic table is not an element. A quick check of the periodic table reveals that water is not listed, so it is not an element. It must be more complex, made up of two or more different elements. Indeed, if you were to run an electric current through water, you would find that it produces two gases that can be identified as hydrogen and oxygen (Figure 2). Hydrogen and oxygen are both elements on the periodic table. Any pure substance that is composed of two or more different elements that are chemically joined is called a **compound**. Water is a compound of the elements hydrogen and oxygen.

Figure 2 When an electric current passes through water, the particles of water are split apart, producing two gases—hydrogen and oxygen.

You can already tell from this simple example how useful the periodic table is. It serves as a quick and easy reference to distinguish elements from more complex substances. As Sherlock Holmes would say, "It is elementary, my dear Watson."

Elements are the building blocks of all substances. If you think of elements as the letters in an alphabet, then compounds are the words that the letters spell. Think of all the words that can be created from just 26 letters. If there are over one hundred letters in an alphabet, there must be countless words that can be formed. However, just as only certain words exist in a language, only certain combinations of elements are possible. The periodic table can show you the underlying patterns of these combinations. In this chapter, you will evaluate how our theories of the atom can explain these patterns.

TRY THIS ELEMENT SCAVENGER HUNT

SKILLS: Performing, Observing, Analyzing, Communicating

Elements are the building blocks of everything in the world. However, not many of the everyday pure substances we encounter are elements. Most substances are compounds. In this activity, you will see how many different elements you can find and determine whether any interesting patterns emerge when you arrange them on a periodic table.

Equipment and Materials: **Gather as many elements as possible from home: from your kitchen, your tool box, your wallet, or your jewellery box. Some elements that are not available at home may be available at school and provided by your teacher. The following list is a suggested collection. From school, obtain magnesium, sulfur, and silicon. From home, obtain copper, iron, nickel, aluminum, tin, silver, gold, zinc, carbon, and air (containing the elements oxygen, nitrogen, argon) (Figure 3).**

Figure 3 Elements are everywhere!

1. If a large wall-size periodic table is available, place it flat on a table or floor. As a class, place small samples of each element in the corresponding location on the periodic table.
2. If a large periodic table is not available, cut out identical squares of paper. Place a small sample of each element on a paper square labelled with the element's name. As a class, arrange the squares on a table or floor to their corresponding location on the periodic table.
3. For each of the following, answer the question and describe the area in the periodic table in which the elements are located; for example, in the centre, in the first column, and so on.

A. Which elements require careful storage and handling? K/U

B. Which elements have been used throughout history to make coins and jewellery? K/U

C. Which elements are metallic in appearance? K/U

D. Which elements are not metallic in appearance? K/U

E. Are there any elements that are difficult to classify as metallic or not metallic in appearance? Which ones? K/U

F. Which elements are gases? Is there a pattern in the way the gaseous elements are arranged on the periodic table? Give reasons for your answer. K/U C

Metals and Non-Metals

metal an element that is lustrous, malleable, and ductile, and conducts heat and electricity

When you look at a collection of elements, some elements appear metallic and others do not. For example, copper, silver, and gold have the shiny lustre that we identify as metallic, and so do iron, aluminum, magnesium, nickel, and tin. The elements lithium, sodium, and potassium often have a white coating on the surface. However, when these elements are freshly cut, they reveal their beautiful metallic sheen. In general, **metals** are elements that are located on the left and central parts of the periodic table. They are solids that display a metallic lustre. The metals in Figure 4, from left to right, are beryllium, magnesium, calcium, strontium, and barium.

Figure 4 Metals are solids that display a metallic lustre.

Non-metals are elements that are not metallic. Non-metals are found in the upper right portion of the periodic table. They are mostly gases and dull powdery solids. The only liquid non-metal is bromine, element 35 (Figure 5). A bold line that resembles a downward staircase, starting at boron, separates the metals and non-metals on the periodic table (Figure 6). Elements located along the staircase line are called **metalloids** because they have properties of both metals and non-metals.

non-metal an element, usually a gas or a dull powdery solid, that does not conduct heat or electricity

metalloid an element that has properties of both metals and non-metals

Figure 5 Non-metals are mostly gases and dull, powdery solids. The non-metals shown here are phosphorus (white and red), oxygen, carbon, sulfur, iodine, and bromine.

Metals exhibit other physical properties besides being shiny. Pots and pans are made of metals because metals are easy to shape and excellent conductors of thermal energy. Copper is used in electrical circuits because it conducts electricity. Copper is also very flexible and ductile, which allows it to be pulled into wires. The lustre and malleability of gold and silver, and their resistance to corrosion, make them ideal for decorative and valuable objects, such as jewellery and coins. Gold is so malleable that it can be pounded into sheets as thin as tissue paper. These sheets of gold foil are used in paintings, sculptures, and decadent desserts (Figure 7).

Non-metals are clearly distinguishable from metals. Many non-metals, such as nitrogen, oxygen, and hydrogen, are gases at room temperature. Non-metals that are solids are not shiny, ductile, or malleable. Consider a charcoal briquette as an example (Figure 8). It is mainly composed of carbon, a non-metal. It is dull and brittle, and shatters easily if pounded or stretched.

13	14	15	16	17	18
					He
B	C	N	O	F	Ne
Al	Si	P	S	Cl	Ar
Ga	Ge	As	Se	Br	Kr
In	Sn	Sb	Te	I	Xe
Tl	Pb	Bi	Po	At	Rn

Figure 6 Metals (blue) are located to the left of the staircase line of the periodic table. Non-metals (red) are located on the right. Metalloids (green) are located along the staircase line.

Figure 7 Gold leaf has many interesting applications.

Figure 8 A charcoal briquette is made up of 85 % to 98 % carbon. Carbon, a non-metal, is dull and brittle.

Non-metals are generally poor conductors of thermal energy and electricity. (Carbon is an exception.) We take advantage of this non-conducting property of non-metals to insulate our houses in winter. Inserting a layer of a non-metal, such as argon gas, between the two panes of glass in double-glazed windows greatly reduces the thermal energy loss through glass alone. You apply the same principle when you put on a warm sweater. The layer of air trapped in the loops of yarn, and between the sweater and your body, decreases your body's loss of thermal energy.

CITIZEN ACTION

Recycle Your Cellphone, Save a Gorilla

Do gorillas use cellphones? Not that we know of, but their lives are closely linked to an element called tantalum, a key component of almost all cellphones, pagers, and laptops. Tantalum is a metal that is lightweight and can hold a high electrical charge (Figure 9). These properties make it an ideal material for the miniature circuit boards in electronic devices. Unfortunately, the ore for tantalum is mined mostly in the rainforests of central Africa, where the endangered lowland gorillas live (Figure 10).

Figure 9 Tantalum is used in electronic devices such as cellphones because it is lightweight and can hold a high electrical charge.

Figure 10 The lowland gorillas of central Africa are endangered because of the mining boom for tantalum.

The growing worldwide demand for cellphones, and hence tantalum, has brought thousands of miners into protected parks. Mining destroys habitat and threatens wildlife. Worse, the slow-moving and meaty gorillas are hunted and killed as food for the miners. There has been an estimated 70 % decline in the population of the eastern lowland gorilla since the mining boom began.

Recycling old cellphones allows tantalum to be reclaimed and reused, thus reducing the need for further mining. Cellphones also contain valuable minerals, such as gold, which can be profitably recovered as well. Refurbishing and reusing cellphones also protects landfill sites from hazardous components, including antimony, arsenic, cadmium, copper, lead, and zinc. When these elements are burned or buried in landfills, they pollute our air and leach into our soil and water supplies, eventually entering our food chain.

It is estimated that the average Canadian teenager will buy and discard three cellphones during their years in high school, and there are several million teenagers across Canada. New phone purchases are not made out of necessity, but rather for upgrades as new features and trendy models come on the market.

Organizing a cellphone recycling program can be a simple and effective way to help our environment and reduce mining for tantalum. The gorillas will thank you.

What Can You Do To Help?

- Start a cellphone recycling program at your school.
- Make and display posters educating about cellphone recycling at local businesses in your community.
- Organize a competition to design and build creative collection boxes where used cellphones can be dropped off for recycling. Place these boxes around the school or at local businesses and shopping malls.
- Write an article for your school newspaper or a letter to a local newspaper informing readers about cellphone recycling.
- Encourage family and friends to participate in your school recycling program.
- Most cellphone companies accept used cellphones for recycling. Contact a local store to arrange for pickup of your collected cellphones.
- Contact the Toronto Zoo for information about the EcoCell program, a worldwide cellphone recycling program that helps to restore the habitat of lowland gorillas in Africa.
- Organize a trip to the Toronto Zoo to deliver cellphones collected for recycling and to visit the lowland gorilla exhibit.
- Think of ways to reduce the number of new cellphones you buy.

UNIT TASK Bookmark

You can apply what you learned in this section about elements and compounds to the Unit Task described on page 286.

IN SUMMARY

- An element is a pure substance that cannot be broken down into a simpler chemical substance by any physical or chemical means. Elements are the building blocks of all substances and are arranged on the periodic table.
- A compound is a pure substance composed of two or more different elements.
- A metal is an element that has lustre, is a conductor, and is malleable and ductile.
- A non-metal is an element that is usually a gas or a dull powdery solid. Non-metals are usually poor conductors of heat and electricity.
- A metalloid has both metallic and non-metallic properties.

CHECK YOUR LEARNING

1. Which of the following substances are elements? Explain how you determined your answer. K/U
   (a) bronze
   (b) tin
   (c) chromium
   (d) solder
   (e) propane
   (f) arsenic
   (g) nickel
2. What is the difference between an element and a compound? K/U
3. A white powder, when heated, produces a colourless gas and a black solid. Is the white powder an element? Give reasons for your answer. T/I
4. Explain the significance of the bold staircase line on the periodic table (Figure 11). K/U

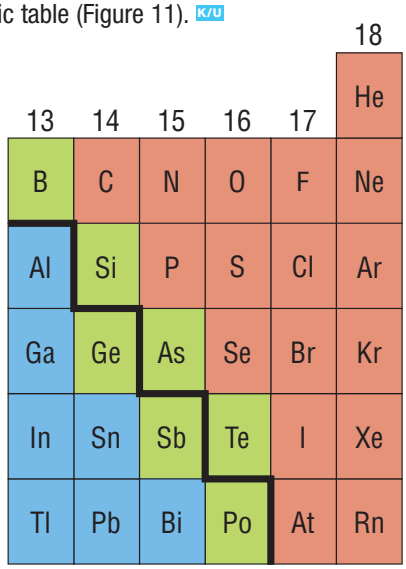

Figure 11

5. Are there more metallic elements or non-metallic elements listed on the periodic table? K/U
6. List three properties of metals. K/U
7. List three properties of non-metals. K/U
8. Create a two-column table in your notebook with the headings "Metals" and "Non-metals." Classify each of the properties below as characteristic of metals or non-metals. Include an example from the periodic table for each property. K/U C
   (a) conducts electricity
   (b) is a gas under normal conditions
   (c) can be flattened by hammering
   (d) its symbol is located in the upper-right corner of the periodic table
   (e) shatters when struck
   (f) is a dull yellow powder
   (g) is soft and shiny
   (h) its symbol is located in the first column of the periodic table
9. Identify which properties of each of the following elements make them ideal for their uses. K/U A
   (a) copper and aluminum for pots and pans
   (b) silver and gold for jewellery
   (c) argon in double-glazed windows for homes
10. In this section, you were introduced to some of the physical properties of carbon, a non-metal. K/U
    (a) Describe the physical properties of carbon.
    (b) What property of carbon makes it different from other non-metals?