TOPIC 2.2

How does the periodic table organize the elements?

Key Concepts

- Elements are the building blocks of matter.
- Elements can be organized by their properties.
- The modern periodic table organizes elements in groups and periods.
- Elements are classified as metals, non-metals, or semi-metals.

Curricular Competencies

- Make observations aimed at identifying your own questions, including increasingly complex ones, about the natural world.
- Collaboratively and individually plan, select, and use appropriate investigation methods to collect reliable data.
- Consider the role of scientists in innovation.

Suppose you were given the task of organizing this pile of Lego bricks into various containers. How would you go about it? Would you organize by colour? Shape? Size? How would you arrange your containers once you were finished sorting? Scientists in the mid-1800s faced an organizing challenge as they tried to come up with a principle for arranging the elements based on their known properties.

Starting Points

Choose one, some, or all of the following to start your exploration of this Topic.

1. **Identifying Preconceptions** How many elements can you name? List as many as you can think of. Then list as many physical and chemical properties associated with each element as you can. As a class, share your lists. In what ways could your list be organized?
2. **Evaluating** How many different types of Lego bricks can you see in the photo on this page? What different characteristics define them? When scientists first started trying to come up with a system for organizing the elements, they knew of about 60 elements and their properties. How is organizing a set of Lego by their characteristics similar to organizing elements by their properties? How is it different?
3. **Applying First Peoples Perspectives** The world view of many First Peoples recognizes four elements in nature: earth, air, fire, and water. How do these differ from the elements of Western science? How might Western scientists view the world differently using these elements? How might First Peoples scientists view the world differently using the elements of Western science?

Key Terms

There are five key terms that are highlighted in bold type in this Topic:

- group
- period
- metal
- non-metal
- semi-metal

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

CONCEPT 1

Elements are the building blocks of matter.

Activity

Elements on Brick World

What if you lived in an alternate reality in which the building blocks of matter are Lego bricks, not atoms? Work in groups. Your teacher will give you a set of bricks. Use your set to do the following:

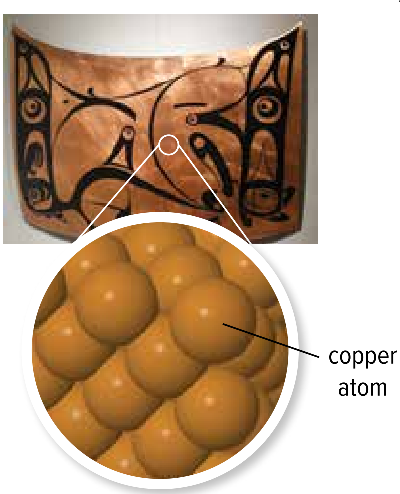
- Make sketches of each “element” and give them names.
- Make models of two different “compounds” using your brick elements.
- Make a model of a mixture that contains two or more brick compounds.

When you are finished, do a gallery walk to see the work of your classmates. What do you notice about the variety of brick elements, compounds, and mixtures?

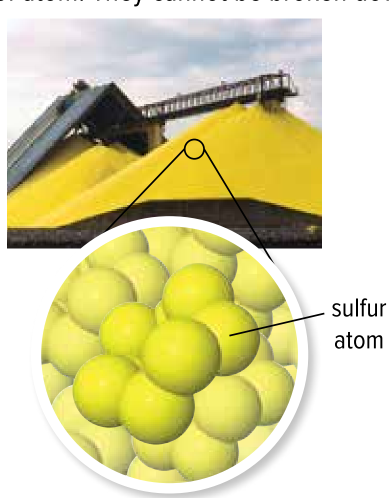
Matter can take many different forms, but all forms of matter can be broken down into a fairly small number of basic building blocks—the elements. On Earth, about 90 elements occur naturally. Carbon, silver, and oxygen are examples of naturally occurring elements. There are also a number of elements that do not exist naturally but have been synthesized in laboratories. Three examples of elements with very different properties are shown in **Figure 2.6**.

Connect to Investigation 2C on page 118

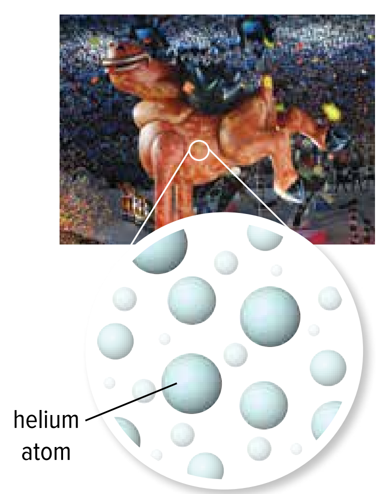
Figure 2.6 Like all elements, copper, sulfur, and helium are each made up of one type of atom. They cannot be broken down further into different substances.



Copper (Cu) is shiny and malleable. This means it can be hammered into thin sheets such as the copper leaf used on this car hood by B.C. artist Michael Nicoll Yahgulanaas. This piece is part of a series called *Coppers from the Hood*.



Sulfur (S) is a powdery, bright yellow solid. The piles shown here in Vancouver harbour are awaiting export overseas. Sulfur is used mainly to make sulfuric acid. Sulfuric acid is used to make many industrial products such as fertilizers, detergents, batteries, and medicines.



This giant floating moose was used in the closing ceremonies of the Vancouver 2010 Winter Olympics. To make it float, it was filled with helium (He), which is a colourless, odourless gas that is less dense than air.

Element Names and Symbols

Each element has a unique chemical name and symbol. The chemical symbol is one or two letters. (Synthetic elements that have not yet been named are given placeholder names and three-letter symbols.) The first letter is always capitalized, and the remaining letter or letters, if any, are always lowercase. The names and symbols of the elements are accepted and used by all scientists worldwide in order to standardize the communication of chemical information. Many element names come from an ancient language called Latin. Others are named for countries or continents (polonium, americium) or to honour scientists of note (bohrium, rutherfordium). The symbols and names of some elements are shown in Table 2.2.

Table 2.2 Symbols and Names of Selected Elements

Name of Element	Element Symbol	Origin of Symbol or Name
carbon	C	*Carbo* = Latin for coal and charcoal. Carbon in the form of soot and charcoal has been known to humans for many thousands of years. 
copper	Cu	*Cuprum* = Latin for cyprium, meaning metal of Cyprus, an island country near Greece. The ancient Romans obtained much of their copper from mines on Cyprus. 
francium	Fr	*France* = Marguerite Perey discovered this element in France in 1939. 
lead	Pb	*Plumbum* = Latin for lead. This element's name has the same root as "plumbing" because the ancient Romans used lead in their plumbing systems. Unfortunately, lead is toxic and their pipes poisoned their water. 
sulfur	S	*Sulphuium* = Latin for sulfur. In Canada, the United States, and Great Britain, there has been some switching back and forth of the name of this element from sulfur to sulphur. The spelling "sulfur" is now considered standard. sulPHur! sulFur!

Before you leave this page . . .

1. How many elements occur naturally on Earth?
2. What distinguishes one element from another?

CONCEPT 2

Elements can be organized by their properties.

Activity

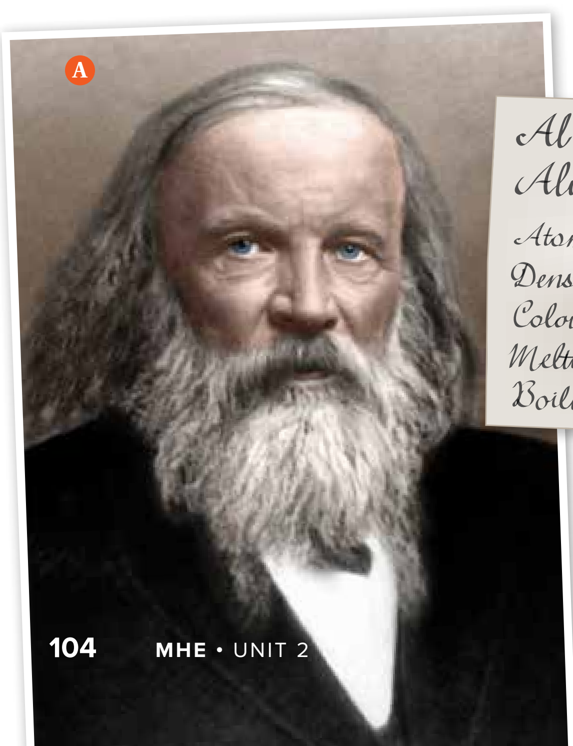
Element Cards

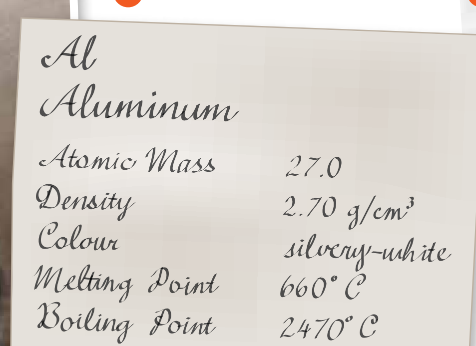
Work in groups. Your teacher will give your group a set of cards. On each card is an element and information about its properties. Your challenge is to arrange the cards in rows and columns in a way that makes sense to you and your team members. When you are finished, explain your reasoning to the rest of the class.

In the mid-1800s, scientists had identified nearly 60 elements, and nobody knew how many more there might be. Scientists needed a classification system that would organize their observations. They were already grouping elements into "families" based on similar properties, but many family relationships were not obvious. What else could a classification system be based on?

By the 1860s, some scientists were trying to sort the known elements according to atomic mass. *Atomic mass* is the average mass of an atom of an element. Among them was a Russian chemist named Dmitri Mendeleev (1834–1907).

To help him experiment with different ways to organize the elements, Mendeleev made a card for each one. On each of these cards, he put data similar to the data you see in **Figure 2.7**. He shuffled and reordered the cards, playing a game of "chemical solitaire" to try to make sense of the repeating patterns of properties.





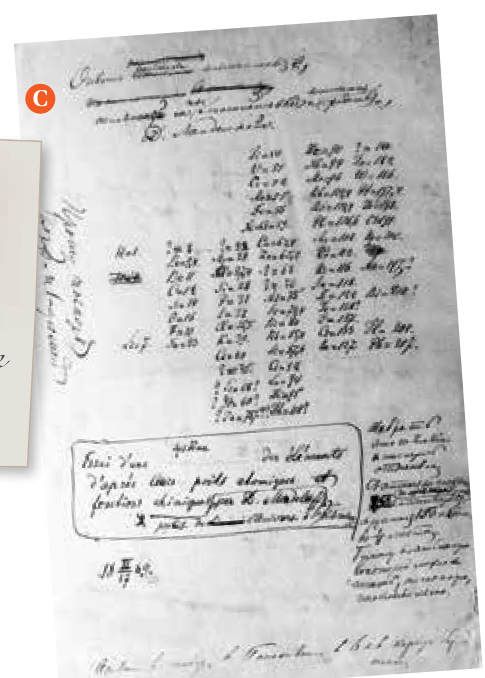
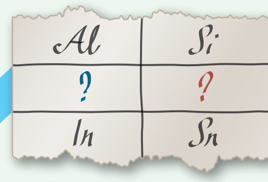


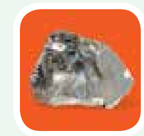
Figure 2.7 A Dmitri Mendeleev was a Russian teacher and chemist. He was the youngest of 17 children. B Mendeleev wrote the properties of elements on cards like this one so he could rearrange them and compare properties. C These are some of his original notes.

Mendeleev's Table



Properties of Gallium

Property	Mendeleev's Prediction	Actual Data
Atomic mass	68	69.72
Density (g/cm^3)	6.0	5.904
Melting point (°C)	low	29.78



Properties of Germanium

Property	Mendeleev's Prediction	Actual Data
Atomic mass	72	72.61
Density (g/cm^3)	5.5	5.32
Melting point (°C)	high	947

Figure 2.8 The gaps in Mendeleev's table predicted the existence of yet-to-be-discovered elements. Mendeleev used the properties of other elements in the same families to predict the properties of these elements.

The Predictive Power of Mendeleev's Table

After several months of "chemical solitaire," Mendeleev arrived at an arrangement that organized the elements according to their properties. Like other scientists before him, Mendeleev knew that the properties of elements tended to repeat over regular intervals. Like other scientists, he was ordering the elements by increasing atomic mass. However, Mendeleev realized that he needed to leave gaps in his arrangement—blank spaces predicting the existence of elements not yet found or even suspected by other chemists.

Using these gaps, he was able to accurately predict properties of elements that were not yet known but would be discovered later, including scandium, gallium, and germanium. How did Mendeleev's table make it possible for him to predict the properties of undiscovered elements? Mendeleev noted which families had spaces. He inferred that the missing elements would have properties similar to those of other members of their family. Gallium and germanium, shown in **Figure 2.8**, are famous for having been discovered after Mendeleev predicted their existence and physical properties.

Extending the Connections

Other Contributors to the Periodic Table

Research to find out how other scientists contributed to the development of the periodic table. Choose one of the following scientists: John Dalton, Alexandre Béguyer de Chancourtois, John Newlands, Julius Lothar Meyer, or Henry Moseley.

Before you leave this page . . .

1. Why did Mendeleev leave gaps in his periodic table?
2. How was Mendeleev able to predict the properties of gallium and germanium?

Figure 2.9 The modern periodic table enables the presentation of a wealth of information about each element on a single page.

Periodic Table of the Elements

metal

semi-metal

non-metal

Atomic Number → 22; Symbol → Ti; Name → Titanium; Atomic Mass → 47.9; Ion charge(s) → 4+ 3+

O natural

Db synthetic

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H Hydrogen 1.0 1+																	2 He Helium 4.0 0
2	3 Li Lithium 6.9 1+	4 Be Beryllium 9.0 2+											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0 3–	8 O Oxygen 16.0 2–	9 F Fluorine 19.0 1–	10 Ne Neon 20.2 0
3	11 Na Sodium 23.0 1+	12 Mg Magnesium 24.3 2+											13 Al Aluminum 27.0 3+	14 Si Silicon 28.1	15 P Phosphorus 31.0 3–	16 S Sulfur 32.1 2–	17 Cl Chlorine 35.5 1–	18 Ar Argon 39.9 0
4	19 K Potassium 39.1 1+	20 Ca Calcium 40.1 2+	21 Sc Scandium 45.0 3+	22 Ti Titanium 47.9 4+ 3+	23 V Vanadium 50.9 5+ 4+	24 Cr Chromium 52.0 3+ 2+	25 Mn Manganese 54.9 2+ 3+ 4+	26 Fe Iron 55.8 3+ 2+	27 Co Cobalt 58.9 2+ 3+	28 Ni Nickel 58.7 2+ 3+	29 Cu Copper 63.5 2+ 1+	30 Zn Zinc 65.4 2+	31 Ga Gallium 69.7 3+	32 Ge Germanium 72.6 4+	33 As Arsenic 74.9 3–	34 Se Selenium 79.0 2–	35 Br Bromine 79.9 1–	36 Kr Krypton 83.8 0
5	37 Rb Rubidium 85.5 1+	38 Sr Strontium 87.6 2+	39 Y Yttrium 88.9 3+	40 Zr Zirconium 91.2 4+	41 Nb Niobium 92.9 3+ 5+	42 Mo Molybdenum 95.9 2+ 3+	43 Tc Technetium (98) 7+	44 Ru Ruthenium 101.1 3+ 4+	45 Rh Rhodium 102.9 3+ 4+	46 Pd Palladium 106.4 2+ 4+	47 Ag Silver 107.9 1+	48 Cd Cadmium 112.4 2+	49 In Indium 114.8 3+	50 Sn Tin 118.7 4+ 2+	51 Sb Antimony 121.8 3+ 5+	52 Te Tellurium 127.6 2–	53 I Iodine 126.9 1–	54 Xe Xenon 131.3 0
6	55 Cs Cesium 132.9 1+	56 Ba Barium 137.3 2+	57 La Lanthanum 138.9 3+	72 Hf Hafnium 178.5 4+	73 Ta Tantalum 180.9 5+	74 W Tungsten 183.8 6+	75 Re Rhenium 186.2 4+ 7+	76 Os Osmium 190.2 3+ 4+	77 Ir Iridium 192.2 3+ 4+	78 Pt Platinum 195.1 4+ 2+	79 Au Gold 197.0 3+ 1+	80 Hg Mercury 200.6 2+ 1+	81 Tl Thallium 204.4 1+ 3+	82 Pb Lead 207.2 2+ 4+	83 Bi Bismuth 209.0 3+ 5+	84 Po Polonium (209) 2+ 4+	85 At Astatine (210) 1–	86 Rn Radon (222) 0
7	87 Fr Francium (223) 1+	88 Ra Radium (226) 2+	89 Ac Actinium (227) 3+	104 Rf Rutherfordium (265)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

58 Ce Cerium 140.1 3+ 4+	59 Pr Praseodymium 140.9 3+ 4+	60 Nd Neodymium 144.2 3+	61 Pm Promethium (145) 3+	62 Sm Samarium 150.4 3+ 4+	63 Eu Europium 152.0 3+ 2+	64 Gd Gadolinium 157.3 3+	65 Tb Terbium 158.9 3+ 4+	66 Dy Dysprosium 162.5 3+	67 Ho Holmium 164.9 3+	68 Er Erbium 167.3 3+	69 Tm Thulium 168.9 3+ 2+	70 Yb Ytterbium 173.0 3+ 2+	71 Lu Lutetium 175.0 3+
90 Th Thorium 232.0 4+	91 Pa Protactinium 231.0 5+ 4+	92 U Uranium 238.0 6+ 4+ 5+	93 Np Neptunium (237) 5+ 3+ 4+ 6+	94 Pu Plutonium (244) 4+ 6+ 3+ 5+	95 Am Americium (243) 3+ 4+ 5+ 6+	96 Cm Curium (247) 3+	97 Bk Berkelium (247) 3+ 4+	98 Cf Californium (251) 3+	99 Es Einsteinium (252) 3+	100 Fm Fermium (257) 3+	101 Md Mendelevium (258) 2+ 3+	102 No Nobelium (259) 2+ 3+	103 Lr Lawrencium (262) 3+

Based on mass of C-12 at 12.00.

Any value in parentheses is the mass of the most stable or best known isotope for elements that do not occur naturally.

CONCEPT 3

The modern periodic table organizes elements in groups and periods.

Activity

Observing the Elements

Turn the page and take a look at the pictorial periodic table shown in **Figure 2.11**. What patterns do you see among elements of the same group (vertical column) and in the same period (horizontal row)?

Today's periodic table, shown in **Figure 2.9** on the left, is strikingly similar to Mendeleev's. The principle behind the order of the elements, though, is different. For the most part, Mendeleev ordered the elements in his table based on increasing atomic mass. But this principle did not work perfectly: he had to place a few elements out of order so that they would appear in the group they seemed to belong to, based on their properties. Later, a scientist called Henry Moseley developed a way to determine the number of positive charges in an atom, which told him the number of protons in the atom. This number is now known as an element's *atomic number*. When arranged according to increasing atomic number, the elements all fit perfectly in the table, with no reordering needed.

Connect to Investigation 2D on page 120

Meet the Modern Periodic Table

The modern periodic table consists of boxes arranged in vertical columns and horizontal rows by increasing atomic number. The box for oxygen is shown in **Figure 2.10**. Mendeleev called the vertical columns of the periodic table families. Today they are often called **groups** and are numbered 1 through 18. The horizontal rows of the table are called **periods**. Beginning with hydrogen in the first period, there are a total of 7 periods.

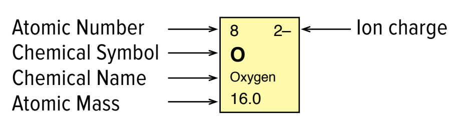


Figure 2.10 A typical box from the periodic table tells you the element's name, symbol, atomic number, and atomic mass. The symbol's font tells you the element's state.

group a vertical column of elements in the periodic table; also called a *family*

period a horizontal row of elements in the periodic table

Before you leave this page . . .

1. What was Moseley's contribution to the periodic table and what problem did it resolve?

2. Give the symbol and atomic number of each of the following elements:
   - **a)** manganese
   - **b)** magnesium
   - **c)** arsenic
   - **d)** astatine

Figure 2.11 This version of the periodic table includes photos of many of the elements.
What property do most of the elements have in common?


He 2 Helium
B 5 Boron
C 6 Carbon
N 7 Nitrogen
O 8 Oxygen
F 9 Fluorine
Ne 10 Neon
Al 13 Aluminium
Si 14 Silicon
P 15 Phosphorus
S 16 Sulfur
Cl 17 Chlorine
Ar 18 Argon
27
Ni 28 Nickel
Cu 29 Copper
Zn 30 Zinc
Ga 31 Gallium
Ge 32 Germanium
As 33 Arsenic
Se 34 Selenium
Br 35 Bromine
Kr 36 Krypton
45
Pd 46 Palladium
Ag 47 Silver
Cd 48 Cadmium
In 49 Indium
Sn 50 Tin
Sb 51 Antimony
Te 52 Tellurium
I 53 Iodine
Xe 54 Xenon
77
Pt 78 Platinum
Au 79 Gold
Hg 80 Mercury
Tl 81 Thallium
Pb 82 Lead
Bi 83 Bismuth
Po 84 Polonium
At 85 Astatine
Rn 86 Radon
109
Ds 110 Darmstadtium
Rg 111 Roentgenium
Cp 112 Copernicium
Nh 113 Nihonium
Fl 114 Flerovium
Mc 115 Muscovium
Lv 116 Livermorium
Ts 117 Tennessine
Og 118 Oganesson
62
Eu 63 Europium
Gd 64 Gadolinium
Tb 65 Terbium
Dy 66 Dysprosium
Ho 67 Holmium
Er 68 Erbium
Tm 69 Thulium
Yb 70 Ytterbium
Lu 71 Lutetium
94
Am 95 Americium
Cm 96 Curium
Bk 97 Berkelium
Cf 98 Californium
Es 99 Einsteinium
Fm 100 Fermium
Md 101 Mendelevium
No 102 Nobelium
Lr 103 Lawrencium

CONCEPT 4

Elements are classified as metals, non-metals, or semi-metals.

Activity

Comparing Conductivity

One property that is used to describe and classify matter is electrical conductivity. Materials that are electrical conductors allow electric current to move through them. Your teacher will give you an electrical conductivity meter and items to test. Make a table like the one below, and predict whether each item will conduct electric current. Then test your prediction. What do you notice about the materials that conduct electric current?

Item	Prediction	Is it a conductor?

The boxes on the periodic table in Figure 2.9 are shaded to show the three broad categories of elements: metals (blue), non-metals (yellow), and semi-metals (green). These classifications are based on similarities in physical and chemical properties within each category. The elements of Groups 1, 2, and 13 to 18 are called *main-group elements* or *representative elements*. The elements in Groups 3 to 12 are called *transition elements*.

Metals

metal typically, an element that is hard, shiny, malleable, ductile, and that conducts electricity and heat; found to the left of the zigzag line on the periodic table

Most of the elements are metals. The **metals** are found on the left side of the zigzag line on the periodic table and are shaded in blue. Except for mercury, metals are solid at room temperature. They are shiny when smooth and clean, and most are silver or grey in colour. They are good conductors of thermal energy and electric current. They are also malleable and ductile, which means they can be beaten into sheets or drawn out into wires.

The two rows of metals shown at the bottom of the periodic table are called the *inner transition metals*. They are normally shown below the table to keep it compact. Figure 2.12 shows two important groups of metals: the *alkali metals*, found in Group 1, and *alkaline-earth metals*, found in Group 2. Notice that although hydrogen is shown as part of Group 1, it is not an alkali metal. Figure 2.13 explains why.

Activity

Predict Properties

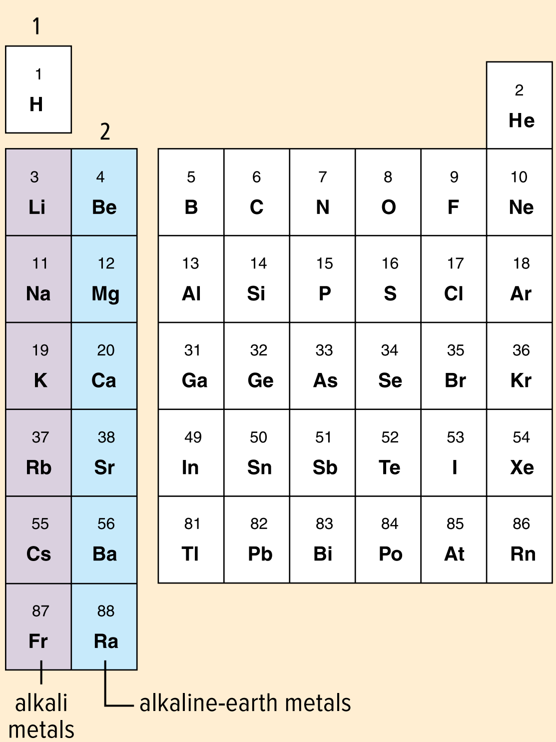
Francium is a rare, unstable alkali metal. It was discovered in 1939, but its existence was predicted by Mendeleev in the 1870s. Use data about the properties of other alkali metals to predict some of francium's properties.

Alkali Metals Data

Element	Melting Point (°C)	Boiling Point (°C)	Atomic radius (pm)
lithium	180.5	1342	152
sodium	97.8	883	186
potassium	63.4	759	227
rubidium	39.3	688	248
cesium	28.4	671	265
francium	?	?	?

1. Come up with a way to clearly display the trends for each of the properties given in the table that will help you to predict a value for francium.
2. Predict whether francium is a solid, a liquid, or a gas at room temperature. How can you support your prediction?
3. Which of the following atomic radii is most likely to belong to francium: 252 pm, 270 pm, or 283 pm? Explain your prediction.

Figure 2.12 This periodic table has been cropped to show only the main-group elements. **What are some differences and similarities between the alkali metals and the alkaline-earth metals?**



Alkali Metals

The elements of Group 1, except for hydrogen, are known as the alkali metals. They are shiny and soft—soft enough to be cut easily with a butter knife. Alkali metals are highly reactive with many substances, including water and oxygen. This reactivity is why pure alkali metals are stored in a non-reactive liquid such as kerosene or oil.

Alkaline-earth Metals

All of the elements of Group 2 are alkaline-earth metals. They are shiny and soft, but not as soft as the alkali metals. Alkaline-earth metals are also highly reactive, but not as reactive as the alkali metals. For example, magnesium does not need to be stored in a non-reactive liquid, but it burns easily in air when ignited, as shown here.

Non-metals

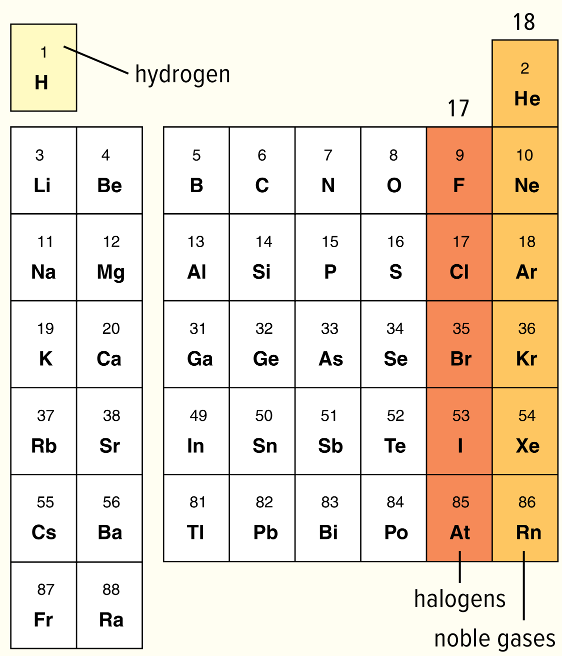
The **non-metals** are found on the upper right side of the periodic table. Hydrogen, which is found in the upper left, is also a non-metal. In the periodic table in Figure 2.9, the nonmetals are shaded in yellow. Non-metals are elements that are generally gases or brittle, dull-looking solids. They are poor conductors of heat and electric current. Figure 2.13 shows hydrogen as well as two important groups of non-metals: the *halogens* and the *noble gases*.

non-metal typically, an element that is not shiny, malleable, or ductile, and is a poor conductor of electric current and heat; found to the right of the zigzag line on the periodic table

Figure 2.13 Halogens, the Group 17 elements, are highly reactive. The defining characteristic of noble gases, the Group 18 elements, is that they are unreactive.

Hydrogen: A Special Case

Hydrogen is usually placed on the left side of the periodic table. However, hydrogen is a non-metal, not a metal. The lightest element, hydrogen is a colourless, odourless, tasteless, and highly flammable gas. Hydrogen makes up over 90 percent of the atoms in the universe. On Earth, most hydrogen is found combined with oxygen as part of the compound water.



Halogens

The halogens are the elements of Group 17. These non-metals are highly reactive, which means they are usually found in nature as part of compounds. Bromine, shown here, is the only non-metal element that is a liquid at room temperature.

Noble Gases

The noble gases are the elements of Group 18. They are all odourless, colourless gases. They are the least reactive of all of the elements. Helium and neon never form compounds, and the other noble gases form compounds only with great difficulty. Incandescent light bulbs are filled with argon because the argon does not react with the tungsten filament in the bulb.

Semi-metals

The elements in the green boxes in a staircase shape are called the **semi-metals** or *metalloids*. Semi-metals are the in-between elements—they have physical and chemical properties of both metals and non-metals. For example, like metals, they are shiny solids at room temperature. But semi-metals are brittle and not ductile like non-metals. They also tend to be poor conductors of heat and electric current. Figure 2.14 shows some important applications of semi-metals.

semi-metal an element that shares some properties with metals and some properties with non-metals

Extending the Connections

What makes silicon special?

Silicon is so important to the electronics industry that an area near San Francisco that has become a hub of this industry is nicknamed "silicon valley." What properties make silicon so important in the manufacture of electronics? Can other semi-metals be used in similar ways? Research to find out.

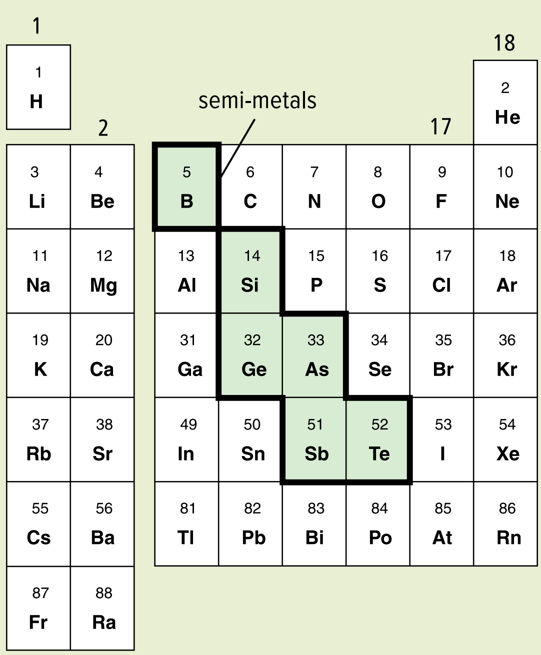
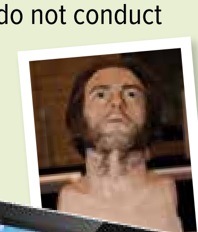


Figure 2.14 Semi-metals have some metallic properties and some non-metallic properties. Some of their properties are in-between. For example, semi-metals do not conduct electric current as well as metals, but they are better conductors than non-metals.



Semi-metals

The semi-metals are boron, silicon, germanium, arsenic, antimony, and tellurium. Silicon is the second-most abundant element in Earth's crust (after oxygen). It has many applications in electronic devices including computers, tablets, and smartphones. Silicon is also used to make silicone, which is part of a huge variety of applications, including car grease, cookware, satellite parts, contact lenses, and film props and prosthetics.

Before you leave this page . . .

1. Make a table to summarize the characteristic properties of metals, non-metals, and semi-metals.
2. What makes hydrogen an unusual element?
3. What characteristics define semi-metals?

AT ISSUE How do trace elements affect our health?

What's the Issue?

There are at least 20 different elements that our bodies need in order to function properly. We can divide them into two groups. There are seven elements known as the major minerals, which are sodium, chloride (ionized chlorine), potassium, calcium, phosphorus, magnesium, and sulfur. There are at least thirteen other elements, known as trace elements, which include iron, zinc, iodine, selenium, copper, manganese, fluoride (ionized fluorine), chromium, and molybdenum. Our body mass includes about 1 kilogram of calcium and about half a kilogram of each of the other major minerals. All the trace elements in our body at any one time have a mass on the order of tens of grams.

We need to ingest major minerals in large amounts of about 100 milligrams per day or more. We need trace elements in very small amounts, between 20 and 0.02 milligrams per day. Of all the trace elements, we need the largest amount of iron and the tiniest amounts of nickel, silicon, vanadium, and cobalt. But just because our bodies do not need trace elements in large amounts doesn't mean they aren't important. They are just as important as the major minerals. Trace elements make up key parts of our bodies' enzymes, hormones and cells. Each one serves a vital function.

We can get the trace element molybdenum by eating legumes.

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. Many Canadians are careful to get the right amount of vitamins and minerals in their diets. Others take supplements to try to achieve this.
   a) Find out what foods different trace minerals are in.
   b) Is taking a trace element as a supplement different than getting it from foods? Explain why or why not.
   c) Can it be harmful to take too much of any one trace mineral, and if so, what are the potential health risks?
2. What are the 13 trace elements? Choose two and research the role each one has in keeping us healthy.
3. Look at labels on packages and cans of food. Read several Nutrition Facts labels. What do you think Percent Daily Value (% DV) means? Which vitamins and minerals must have their % DV listed in the nutrition facts table? Which of these are trace minerals? Why do you think certain nutrients are required to be listed on the table but others are not?

Check Your Understanding of **Topic 2.2**

QP Questioning and Predicting PC Planning and Conducting PA Processing and Analyzing E Evaluating
AI Applying and Innovating C Communicating

Understanding Key Ideas

1. How is the atomic number of an element related to the structure of an atom of that element? PA C

2. List five pieces of information that are recorded on a typical periodic table. PA

3. Compare and contrast the alkali metals and alkaline-earth metals. PA

4. Classify each of the following elements as a metal, a non-metal, or a semi-metal.

a) silicon, Si
b) antimony, Sb
c) krypton, Kr
d) mercury, Hg
e) nitrogen, N
f) cesium, Cs
g) lead, Pb

5. Make a Venn diagram to compare physical properties of metals and non-metals. PA C

6. Which group on the periodic table has elements in all three states of matter? Give examples. PA C

7. Describe where on the periodic table you find the following: PA C

a) metals
b) non-metals
c) semi-metals

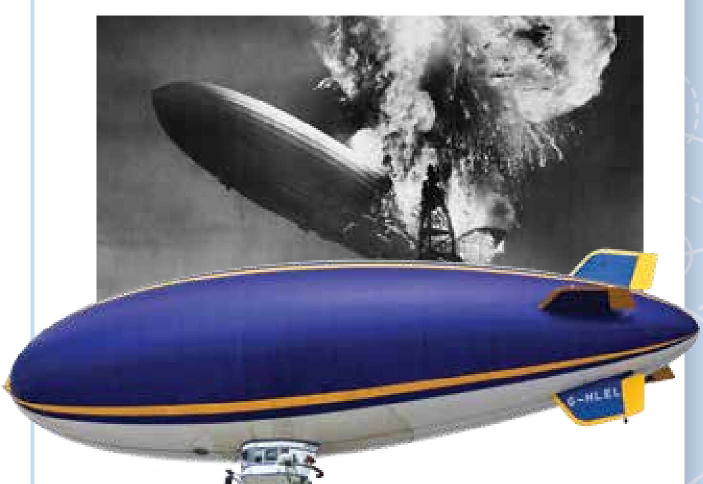
Connecting Ideas

8. Anishnabae Elder Betty McKenna has said that “we contain all those little bits and pieces that’s out there. We have calcium, we have salt, we have iron, we have copper, zinc and potassium.... [We] go from the universe right down to Mother Earth and that’s us.” How does this quote relate to what you have learned about the elements? E C

Making New Connections

9. In the past, gold rushes in British Columbia and elsewhere saw large numbers of everyday people travelling long distances, hoping to find veins of pure gold. Gold is somewhat unusual among metals—most have to be extracted from compounds and are not found in their elemental form, as gold is. What does this tell you about the reactivity of gold? E C

10. On May 6, 1937, a passenger airship called the *Hindenburg* caught fire and crashed, killing nearly half of its passengers as well as one person on the ground. The airship was filled with hydrogen gas. Although people disagree about the sequence of events that led to the disaster, the combustibility of the hydrogen likely contributed. PA E AI



a) What property of hydrogen would have led to its use in airships?

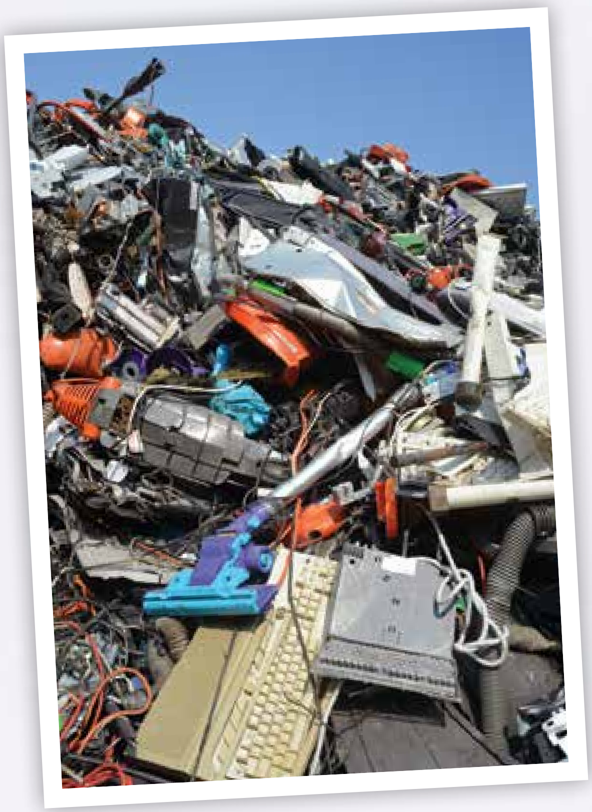
b) Helium is the gas used today for airships. What property of helium makes it more suitable for use in airships than hydrogen?

TAKE Action

Make a Difference

Campaign to Reduce E-waste

Electronics are all around us: our computers, cellphones, electronic readers, tablets … It's difficult to imagine a world without them. Every year more and more electronic equipment and batteries are produced for our use. What this also means, of course, is that every year large amounts of electronics are being discarded as waste. Worldwide, this electronic waste (or e-waste) is skyrocketing. In Canada alone, in 2002, we produced over 11 million tonnes of electronic waste. Ten years later, this number had climbed to 14.3 million tonnes produced in a year.



Is e-waste garbage?

E-waste includes batteries and electrical and electronic equipment such as cameras, microwaves, printers, radios, speakers, and telephones. But just because we call it "waste," it doesn't mean it should be treated as garbage to be lugged away to the landfill site.

Electronic devices contain metals and other elements such as lead, cadmium, barium, chromium, mercury, and arsenic that can be harmful. For example, when chromium exists in compounds as the ion chromium(VI), it can easily be absorbed into our bodies, where it can cause permanent eye injury and even DNA damage over time.

How do these substances come to be absorbed into human bodies? Worldwide, large amounts of e-waste are still dumped into regular landfill sites where it breaks down and the hazardous substances are permitted to leach into the soil or water. In some places, people burn the e-waste to extract metals for resale. Toxins can become airborne, or may be left behind in the ash. The land, water, and air become polluted, and plants, fish, and other animals, including humans, can be harmed or killed by taking them in.

Diverting e-waste from landfills

What's the alternative? Instead of being thrown away, many intact electronics can be repaired or re-used. In addition, many parts of electronic equipment can be recycled to make new parts. Or, the materials making up the equipment—

including glass, steel, plastic, aluminum, and copper—can be recycled. People can dispose of them at special recycling centres so they can be directed to this purpose. Recycling helps to conserve natural resources. It also saves the energy that would have been required to produce new equipment.

There are several regulated programs for e-waste in Canada that allow us to dispose of our e-waste safely. Many jurisdictions offer e-waste pick-up days from specific locations or provide collection sites. Specialized recyclers take them away for safe processing.

Planning for Your Campaign

Your task is to run a campaign to educate your fellow students and their families about the importance of reducing e-waste—and motivate them to take part. Research successful campaigns. Think about how to target and influence your specific local audience. Questions to consider when developing your campaign can include the following:

- Will you work on your campaign alone or would it be more effective to get one or more partners? How will you do that? How will you agree on your roles?
- How can you ensure that your target audience connects with your campaign? Should you focus on one or two specific types of electronics that they use primarily? If so, how can you find out what these are?
- How can you convince your target audience that this issue is important? What information do you need to investigate and learn about?
- Many successful campaigns use posters, slogans, videos, or websites. How will you communicate your message?
- What catchy title and graphics can you use?
- How can you evaluate the success of your campaign?

Write out your plan and, with your teacher's approval, carry it out.

Analyze and Evaluate

1. How successful was your plan? How well did your evaluation plans help you to determine its success?
2. What did you learn that could help you to improve your campaign?

Apply and Innovate

3. Suppose other schools in your province learn of your successful campaign and want to do something similar. They have asked you for advice. Write a short bullet-point list of tips and strategies. Don't be afraid to inform them of areas where you were less successful; you can use what you learned to help guide them toward success.

INVESTIGATION

2-C

GUIDED INQUIRY

Present an Element at ElementCon

As a world-renowned expert on a particular element, you have been invited to present information about that element at ElementCon—an annual convention for fans of the periodic table.

Question

What can you learn about the history, properties, and applications of an element?

Procedure

1. Your teacher will assign you an element. Use print and online resources to find out all about your element. Be sure to answer the following questions as you research:
   - **a)** What is the name, symbol, and number of the element? What are the origins of its name and symbol?
   - **b)** When and how was the element first discovered?
   - **c)** What are the physical and chemical properties of the element, including the following, if applicable:
     - melting and boiling point
     - density
     - state at room temperature
     - colour
     - texture
     - hardness or softness
     - odour
   - **d)** Where on the periodic table is your element found? Is it a metal, a non-metal, or a semi-metal?
   - **e)** What features define an atom of your element?
   - **f)** Where is the element found?
     - Where in the world and in the universe is it found?
     - Can it be found pure or is it always in compounds?
     - What types of compounds does it form?
     - How can the element be isolated from its compounds?
   - **g)** How is the element used today and how was it used in the past? What is the economic importance of the element in Canada or elsewhere in the world?

Skills and Strategies

- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Communicating

What You Need

- Internet access
- print sources of information on your element
- other materials to be determined by your plan, such as posterboard, markers, other art supplies, a smartphone for recording video

2. Take notes to record the information you find. Record the sources of information you used.

Process and Analyze

1. Did you find conflicting information as you researched? Give one example. How did you decide which source to use?
2. Evaluate the sources you used. Were they
   - trustworthy? Explain how you know.
   - current? Explain how you know.

Apply and Communicate

3. Make a plan to decide how you will present your findings at your “booth” at the ElementCon. You may use one or more of the following ideas to present the information you found.
   - Put up an informative poster with tables and images.
   - Use storytelling to creatively reveal properties and other information about your element.
   - Make a display showing a model of an atom of your element.
   - Create a comic book in which your element is the superhero, with powers and weaknesses related to its chemical and physical properties.
   - Write a clickbait-style “Which element are you?” quiz for classmates to try that has questions relating to the properties of your element that distinguish it from others.
   - Collect and display items that contain your element or that relate to your element in some other way.
   - Make a video in which you explain why your element is interesting, unique, and important.
   - Make a video re-creating the discovery of your element.
   - Create a slide show with photos, text, and music relating to your element.
4. Have your teacher approve your plan before you design your booth. On ElementCon day, your teacher will divide the class in half. Half the class will visit booths, while the other half will present. Then the groups will switch.

INVESTIGATION

2-D

STRUCTURED INQUIRY

Meet the Elements

Skills and Strategies

- Planning and Conducting
- Evaluating
- Applying and Innovating
- Communicating

Safety

- Never eat or drink anything in the laboratory.

What You Need

- a selection of elements and information cards—these elements will include a variety of solid, liquid, and gaseous elements from different families of the periodic table

Most of the matter we interact with every day is in the form of compounds and mixtures. In this investigation, you will observe a number of elements in uncombined form.

Question

How can we distinguish among elements by observing some of their physical and chemical properties?

Procedure

1. Your teacher will give a list of the elements you will be observing. Use this list to prepare a table like the one opposite. (Alternatively, your teacher may provide a table for you to fill out.) Be sure to leave plenty of room for observations.
2. Observe the elements as directed by your teacher. Record properties provided on the information cards. Your teacher may demonstrate additional properties.

Process and Analyze

1. Where within any period do you find the following:
   a) the most dense metals
   b) the most reactive metals
2. Where within any group do you find the following:
   a) the most dense elements
   b) the most reactive elements
3. Many of the elements you examined were metals.
   a) List four properties that most metal elements have in common.
   b) List the elements that are exceptions to the properties you listed above, and explain why.
   c) List the elements that are magnetic.
4. List the elements that conducted electric current. Were they all metals?

Symbol	Element Name	State	Colour	Additional Properties (lustre, malleability, density, conductivity, magnetism)	Group
H					
Li					
Na					

Communicate and Question

5. Summarize your findings about metals and non-metals.
6. What questions do you have about the elements or a specific element as a result of this investigation? Come up with at least three questions. Choose one and do Internet research to find the answer.