2.2 The Periodic Table and Chemical Properties

The periodic table organizes the elements according to their properties. Elements are listed in rows by increasing order of atomic number. Rows are arranged in such a way that elements with similar properties line up in vertical columns. Rows are called periods, and columns are called families or groups. Each element in the table is recorded using its name, symbol, atomic number, atomic mass, and common ion charge(s). Two families of metals are the alkali metals and the alkaline earth metals. Two families of non-metals are the halogens and the noble gases.

Words to Know

alkali metals
alkaline earth metals
atomic mass
atomic number
halogens
metalloid
multiple ion charge
noble gases

Did You Know?

Harriet Brooks (1876–1933) was a Canadian researcher who worked with Ernest Rutherford. She was one of the early scientists who found that a gas being released from the element radium was in fact a new element: radon.

In the 19th century, chemists began looking for a way to organize their observations of the elements. Could elements having similar properties be grouped together? What sort of properties could be used? In 1867, a Russian chemist and teacher, Dmitri Mendeleev (Figure 2.10), wrote down the name of every known element on a separate card, like the one shown in Figure 2.11. He also wrote down properties he thought were important, such as density, colour, melting point, and boiling point. Then he sorted and re-sorted the cards into rows and columns until he found a pattern.

Figure 2.10 Dmitri Mendeleev was a teacher and chemist born in Russia.

Many scientists were trying to organize the elements into a table, but Mendeleev's special insight was that there needed to be holes in the table—places left for elements that had yet to be discovered. From the placement of the holes and the properties of the surrounding elements, Mendeleev was able to predict the properties of elements that were later discovered.

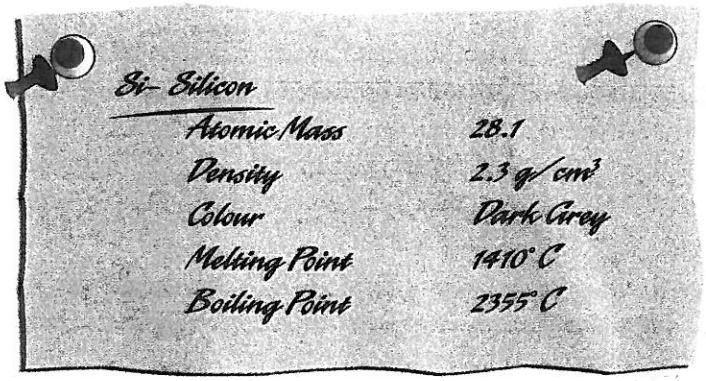

Figure 2.11 Mendeleev wrote down the known properties of each element on a card like this.

2-2A Periodic Puzzle

Think About It

Mendeleev sorted his cards until a pattern emerged. In this activity, you will arrange element cards in groups according to their atomic mass and other properties.

Materials

- element cards provided by your teacher
- scissors

What to Do

1. Use the scissors to cut apart the element cards. Line up the cards in order of increasing mass.
2. Examine the cards to find properties that are similar enough to justify placing certain elements above or below each other in a chemical family.
3. When you are satisfied with your arrangement, explain to a partner how you made your choices.
4. Make any improvements to your classification that you can think of.
5. As a large group, the class must come to a decision as to which classification is the best.

The Periodic Table

We still use Mendeleev's table today, but we call it the periodic table. The **periodic table** is a chart that organizes the elements according to their physical and chemical properties. The periodic table gives each element's name, symbol, atomic number, atomic mass, and ion charge(s) (Figure 2.12).

- The **atomic number** is the number of protons in the nucleus of each atom of an element. It is always a whole number.

  Pattern: Atomic numbers increase one by one through the periodic table. Notice how they start with number 1 at the top left and increase in a regular way down the table (Figure 2.13 on the next page).

- **Atomic mass** is the mass of an average atom of an element. It is always written as a decimal number and is measured in the **atomic mass unit** (amu).

  Pattern: Atomic mass tends to increase along with atomic number. There are some exceptions, such as between cobalt and nickel.

- The **ion charge** is an electric charge that forms on an atom when it gains or loses electrons. Any electrically charged atom is called an **ion**. An atom that has gained electrons is a negative ion because the extra electrons make it negative. An atom that has lost electrons is a positive ion because the loss of electrons removes negative charge. Some elements have a **multiple ion charge**. These elements can form ions in more than one way.

  Pattern: Elements on the left side of the table generally form positive ions. Elements on the right side, except for the last column, generally form negative ions. Elements that are in the same column often form ions with the same charge as other elements in that column.

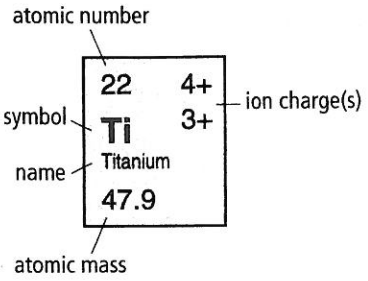

Figure 2.12 Each element has its own box in the periodic table.

Suggested Activity
Think About It 2-2B on page 58

Periodic Table of the Elements

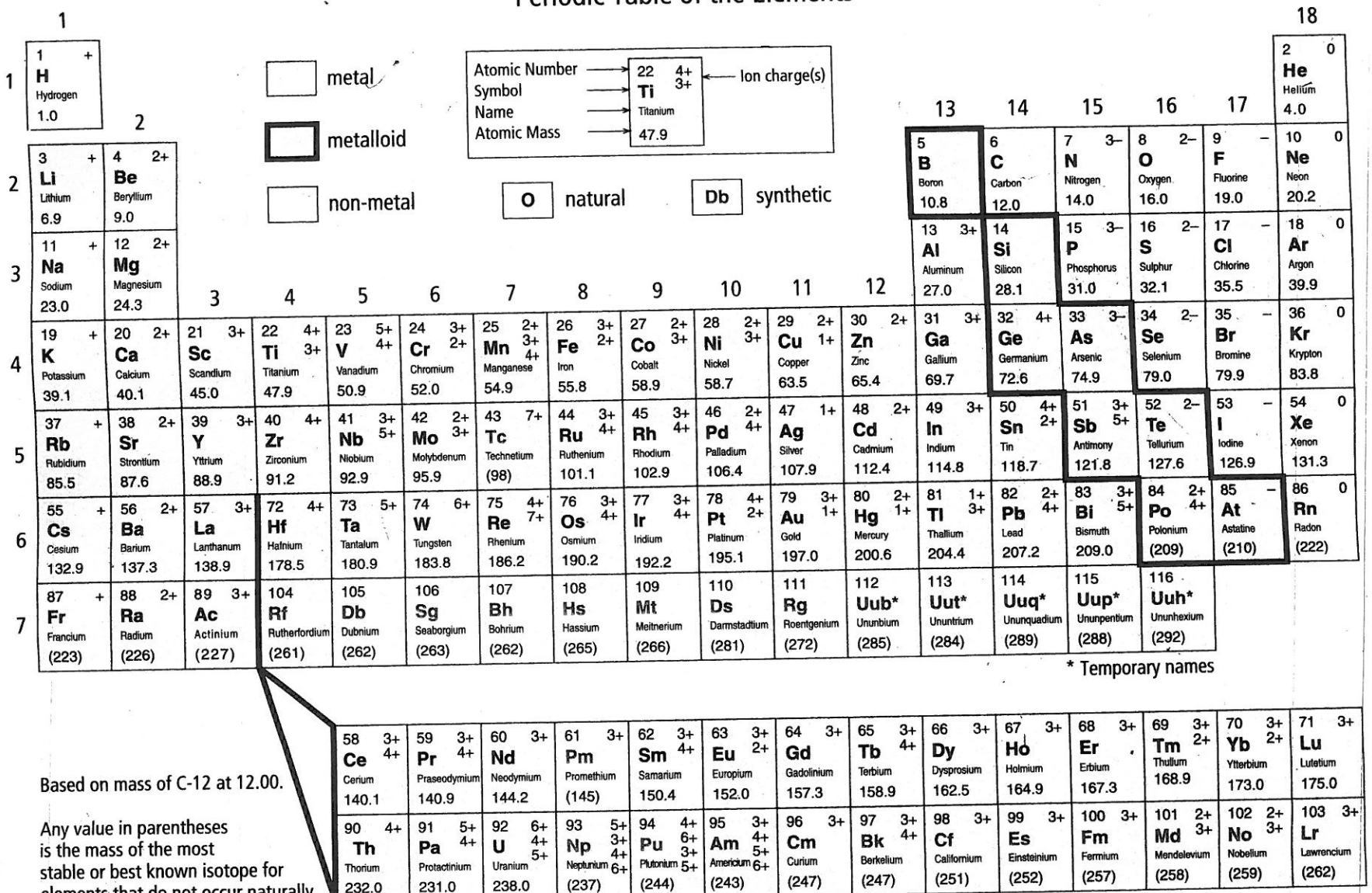

Figure 2.13 The periodic table of the elements

Metals, Non-metals, and Metalloids

Mendeleev arranged the elements according to their properties, which created some interesting patterns. For example, the elements form three groups: metals, non-metals, and metalloids. Notice in Table 2.2 below that **metalloids** are elements that share some properties with metals and some properties with non-metals.

Table 2.2 Properties of Metals, Non-metals, and Metalloids

	State at Room Temperature	Appearance	Conductivity	Malleability and Ductility
Metals	• solid except for mercury (a liquid)	• shiny lustre	• good conductors of heat and electricity	• malleable • ductile
Non-metals	• some gases • some solids • only bromine is a liquid	• not very shiny	• poor conductors of heat and electricity	• brittle • not ductile
Metalloids	• solids	• can be shiny or dull	• may conduct electricity • poor conductors of heat	• brittle • not ductile

A shortened form of the periodic table is shown in Figure 2.14 below that includes the metals, non-metals, and metalloids.

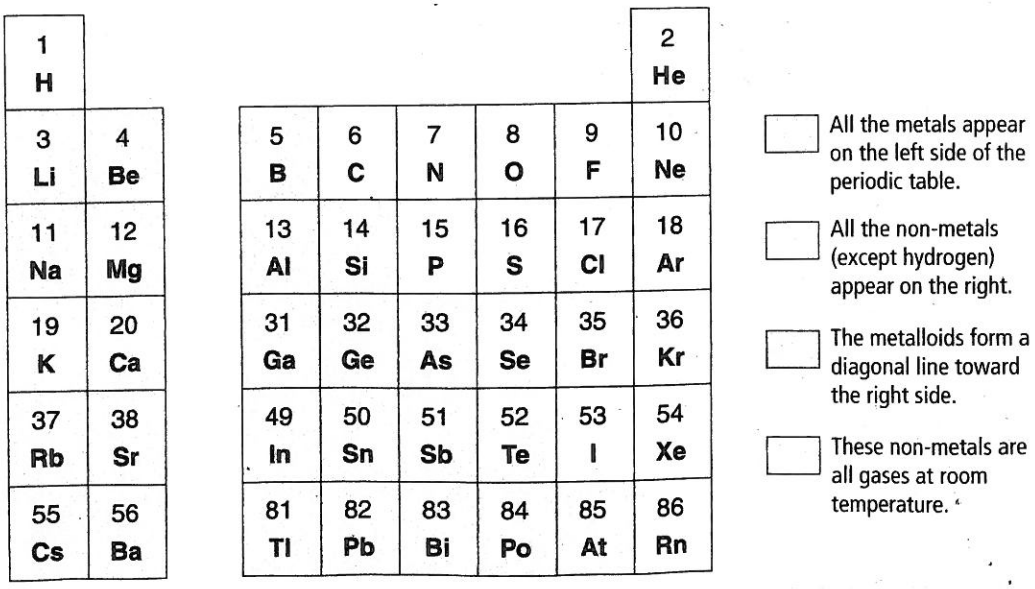

Figure 2.14 The metals, non-metals, and metalloids as they appear in the periodic table

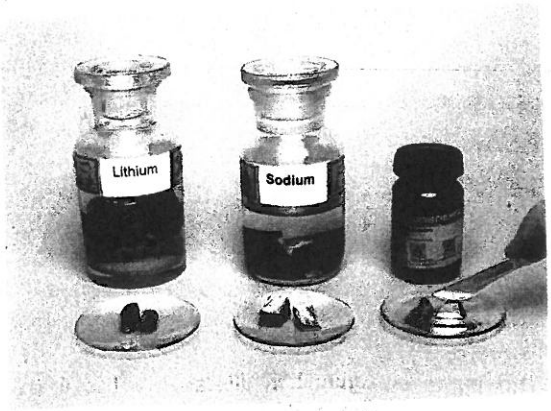

Figure 2.16 Alkali metals are soft and highly reactive.

Periods and Families

Each horizontal row in the periodic table is called a **period**. The periods are numbered from one to seven. For example, hydrogen and helium are in the first period. Lithium is the first of eight elements in the second period.

Chemical families or groups are arranged in vertical columns in the periodic table. Elements in the same **chemical family** have similar physical and chemical properties. The families are in numbered columns 1 to 18 of the table. Four well-known groups are the alkali metals, the alkaline earth metals, the halogens, and the noble gases (Figure 2.15).

Alkali metals (Group 1 excluding hydrogen) Li, Na, K, Rb, Cs, Fr

All the **alkali metals** are highly reactive (Figure 2.16), and reactivity increases as you go down the group. Alkali metals react with both oxygen and water. They have low melting points, all of which are below 200°C. The alkali metals are soft and can be cut with a knife. Cesium is softer and more reactive than lithium.

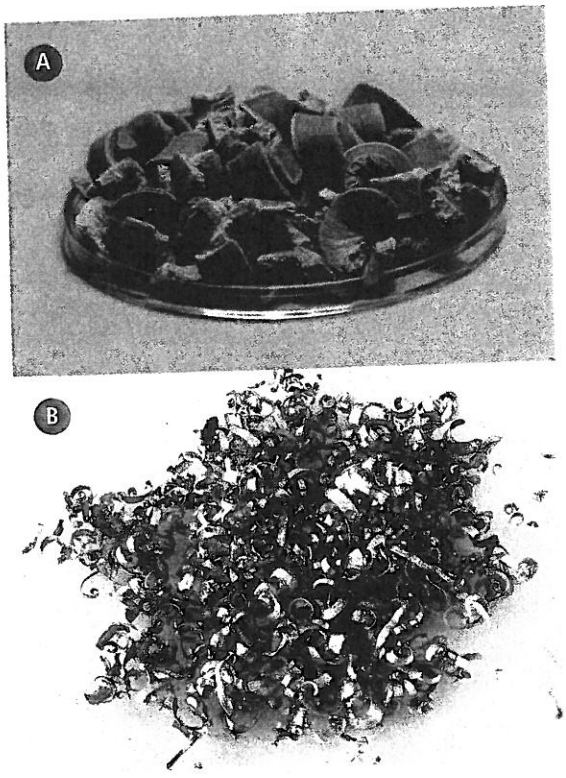

Figure 2.17 Calcium (A) and magnesium (B) are alkaline earth metals.

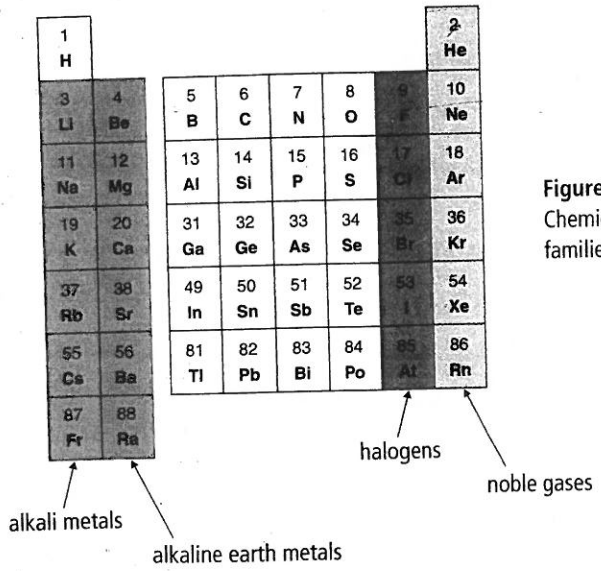

Figure 2.15 Chemical families

Alkaline earth metals (Group 2) Be, Mg, Ca, Sr, Ba, Ra

Alkaline earth metals (Figure 2.17) are less reactive than the alkali metals but will burn in air if heated. They produce bright flames and are used in fireworks. For example, the classic red colour of fireworks is caused by strontium. Alkaline earth metals will also react with water but not as vigorously as alkali metals do. Calcium reacts more quickly than magnesium.

Halogens (Group 17)
F, Cl, Br, I, At

The **halogens** are non-metals and are highly reactive (Figure 2.18). Only fluorine and chlorine are gases at room temperature. Bromine is a liquid and iodine is a solid. Fluorine is the most reactive, and iodine is the least. Astatine is incredibly rare. No one has ever collected enough to determine its physical properties.

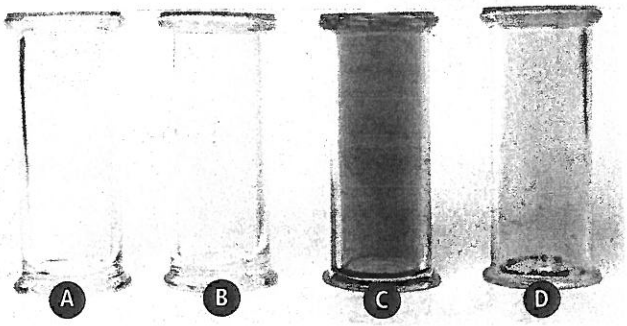

Figure 2.18 The halogens: fluorine (A), chlorine (B), bromine (C), iodine (D)

Noble gases (Group 18)
He, Ne, Ar, Kr, Xe, Rn

The **noble gases** are the most stable and unreactive elements in the periodic table. At room temperature, they are colourless, odourless gases. Some of the gases, such as argon and neon, are used in light fixtures (Figure 2.19). Some, such as neon, glow in distinctive colours. You may know that helium is lighter than air, and that is why helium balloons quickly float out of reach when released.

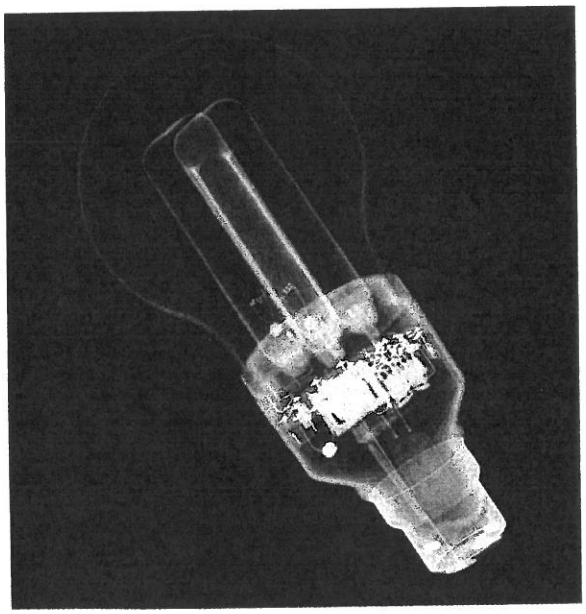

Figure 2.19 The noble gases are stable and unreactive. Argon is used inside the tubes of this energy-efficient fluorescent light bulb.

Reading Check

1. List three pieces of information besides an element's name and symbol that are recorded on a typical periodic table.
2. State how many protons are present in each of the following atoms: (a) silicon, (b) chromium, and (c) iodine.
3. List the following elements by atomic mass from lightest to heaviest: zinc, calcium, cobalt, nickel, carbon. Write the atomic mass beside each one.
4. What is the most common ion charge of chromium?
5. Where on the periodic table do you find the (a) metals, (b) non-metals, and (c) metalloids?

Discovered in 1944, the element americium is used in a common household device that saves many lives every year. Find out more about this device and americium. Begin your research at **www.bcscience9.ca.**