6.3 Classifying Elements with the Periodic Table

The Periodic Table was developed by scientists to organize elements in such a way as to make sense of the growing information about their properties. The first Periodic Table listed the known elements in order of their atomic mass. In doing so, similar chemical and physical properties repeated over and over again. When an element did not fit the pattern based on its properties, a gap was left in the table. As more and more elements were identified, the Periodic Table was adapted to include the new discoveries.

Once the atomic numbers of the elements were determined, elements were ranked in the order of increasing atomic number, and the fit with properties was improved. Today, all of the elements through number 111 have been identified and are shown in the Periodic Table on the inside back cover of this text.

STUDY TIP

Making study notes is important for learning and remembering. As you read this section, look at the headings and subheadings. Turn each subheading into a question and then read to answer it. Record you answers in point form.

To learn about the discovery of new elements to fill the Periodic Table, watch the video clip at **www.science.nelson.com**

Classifying Elements Using Properties

Elements can be classified or grouped in many different ways using physical and chemical properties. For example, physical properties allow elements to be classified as metals, non-metals, or metalloids. Metals have lustre, are generally malleable and ductile, and conduct heat and electricity. Non-metals are not lustrous, are brittle, and do not conduct heat and electricity well. Metalloids have properties of both metals and non-metals (see Table 1).

Table 1 Some Metals, Non-Metals, and Metalloids

Metals	Non-Metals	Metalloids
iron	carbon	boron
aluminum	oxygen	silicon
sodium	sulfur	germanium
gold	neon	arsenic
copper	chlorine	antimony
zinc	phosphorus	tellurium

LEARNING TIP

Check your understanding. Explain to a partner, using the examples in Table 1, how metals, non-metals, and metalloids are alike and how they are different.

Chemical Families

Some groups of elements have characteristic sets of common physical and chemical properties and are called **chemical families**. For example, sodium and potassium are members of the alkali metals family. They are both soft metals with very low density that react with water to form hydrogen. In addition, the compounds formed from elements within a family are very similar in their physical properties. Therefore, sodium chloride and potassium chloride will be similar. Other chemical families include alkaline earth metals, halogens, transition metals, and noble gases. The members of these families and some of their properties are summarized in Table 2.

To learn more about the different chemical families, go to **www.science.nelson.com**

Table 2 Chemical Families and Some of Their Properties

Chemical family	Elements	Properties
Alkali metals	lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), francium (Fr)	• soft metals with very low density • react with water to form hydrogen • form compounds with oxygen that are very basic (alkaline) in solution • lose one electron to form an ion e.g., potassium reacting with water 
Alkaline earth metals	beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), radium (Ra)	• low-density, hard metals • react with water but not as vigorously as the alkali metals • compounds with oxygen are commonly found in rock minerals • lose two electrons to form an ion e.g., pencil sharpener made of magnesium 
Halogens	fluorine (F), chlorine (Cl), bromine (Br), iodine (I), astatine (At)	• highly reactive, toxic non-metals • bright colours as gases • gain one electron to form an ion e.g., iodine subliming to a gas 
Noble gases	helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), radon (Rn)	• very unreactive • colourless, odourless gases • do not readily form ions e.g., helium-filled balloons 
Transition metals	most of the metals in the middle of the Periodic Table	• properties of this group vary significantly • various numbers of electrons lost to form ions e.g., copper pipes 

The Periodic Table Shows Element Groups

The modern Periodic Table provides an excellent way to display the cyclic nature of the elements' properties. Each row is one period or cycle while each column is a group or family with similar properties. The Periodic Table also accommodates the classifications of elements as described earlier. Metals are found on the left side of the table, non-metals on the right side, and metalloids form a zigzag line between the two other classes (Figure 1). Each column is given a group number (Figure 2). GO

Other periodic table formats may be better suited to illustrate different aspects of the properties of elements. To see alternative periodic tables, go to **www.science.nelson.com** GO

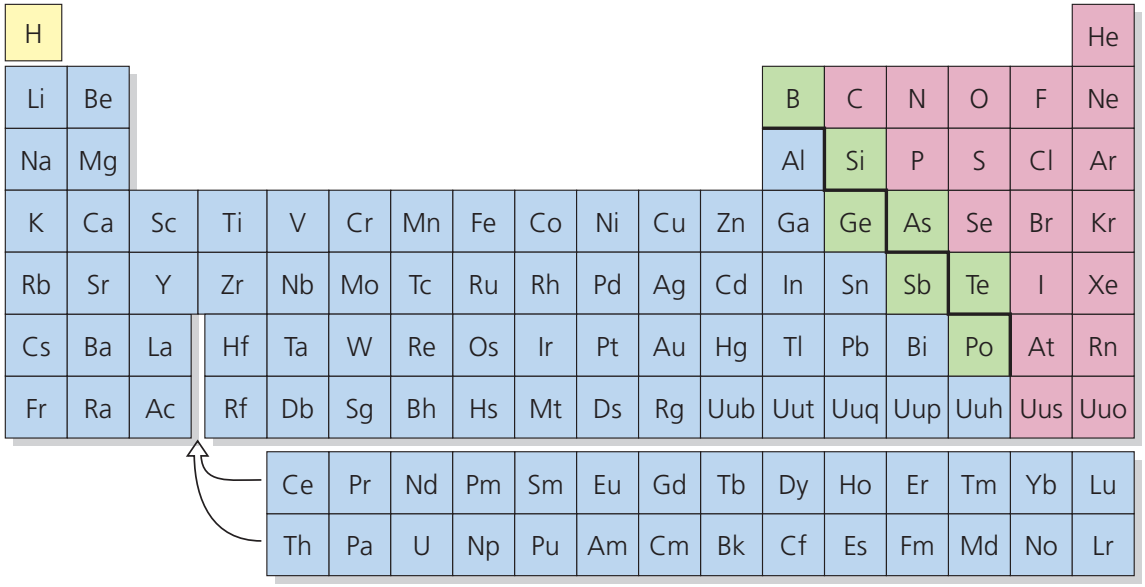

Figure 1 Periodic Table showing metal (blue), non-metal (pink), and metalloid (green) elements

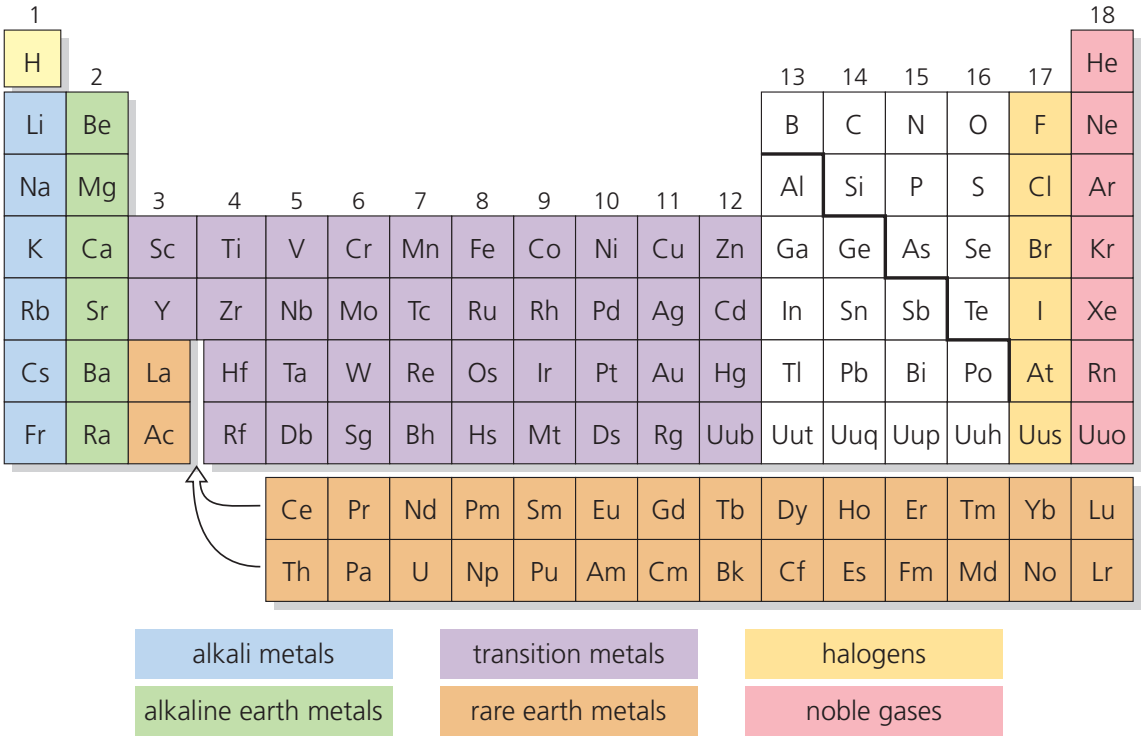

Figure 2 Periodic Table showing major families of elements and group numbers. Not all elements share properties with several other elements, and thus are not easily classified as a chemical family. These elements are indicated in white.

TRY THIS: Bohr Diagrams and the Periodic Table

Skills Focus: creating models, interpreting data

The properties of atoms are correlated to the arrangements of their electrons. In this activity, you will look for the relationship between the outermost shell of atoms and their chemical families.

1. Review the instructions on page 155 for drawing Bohr diagrams.
2. Draw Bohr diagrams for the first 20 elements.

A. Note which elements have only 1 electron in their outer shell. To which chemical family do they belong?

B. Note which elements have 2, 7, or 8 electrons in their outer shell. To which chemical families do they belong?

C. Should oxygen and sulfur be members of the same chemical family? Explain why or why not.

The Periodic Table Shows Electron Configuration

Consider the Bohr models for the first 20 elements. In their outermost shell, all of the elements in Group 1, the first column of the Periodic Table, have 1 electron; all of the elements in Group 2 have 2 electrons, and all of the elements in Group 13 have 3. The pattern continues: in their outermost shell, Group 14 has 4 electrons, Group 15 has 5 electrons, and so on, until Group 18 with 8 electrons. It is the number of electrons in the outermost shell of their atoms that largely determines the properties of the elements. This is understandable, as only these electrons will be in a position to interact with the electrons of another atom. Electrons in the inner shells are shielded from interaction. As you will learn in later chapters, chemical behaviour is determined by this interaction of electrons between atoms.

Compare the number of electron shells needed for an element with its row (or period) in the Periodic Table. Hydrogen and helium need only one shell. Lithium through neon need 2 shells, and so on. The number of shells needed for an element is equal to the row of the Periodic Table in which the element is listed.

To test your knowledge of the Periodic Table, go to **www.science.nelson.com**

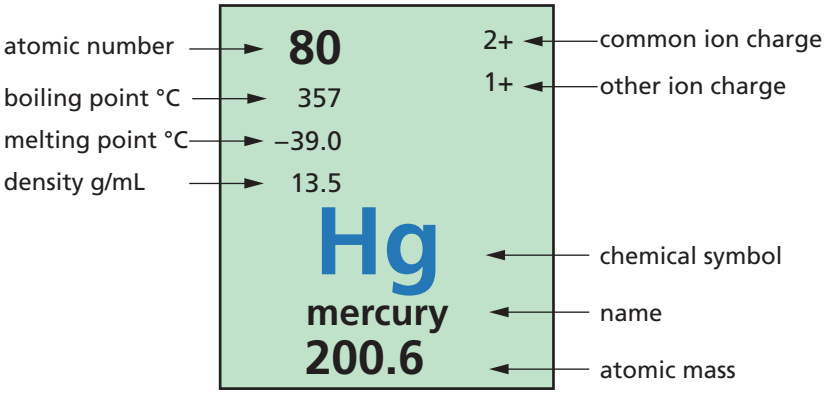

Figure 3 The entry for mercury in the Periodic Table provides several pieces of information.

The Periodic Table Displays Data about Elements

The Periodic Table can be used to display data about the properties of the elements. Besides the atomic number, chemical symbol, name, and atomic mass, the Periodic Table may also include the charges of the common ions (related to the number of electrons gained or lost to form ions), the density, the boiling point and melting point, the electron configuration, or any of the properties of the elements (Figure 3). Exactly which information is included depends on the intended use of the table.

6.3 CHECK YOUR Understanding

1. What criteria are used to order the elements in the modern Periodic Table?
2. Draw a sketch of the Periodic Table and indicate the location of the following groups of elements:
   (a) metals
   (b) non-metals
   (c) metalloids
   (d) halogens
   (e) alkali metals
   (f) noble gases
3. What properties differ between the elements in the alkali metals and the elements in the alkaline earth metals?
4. Explain the difference between a group and a period in the Periodic Table.
5. Elements with only one electron in their outer electron shell (lithium, sodium, etc.) are members of the alkali metal family. Elements which are one electron short of a full outer shell (fluorine, chlorine, etc) are members of the halogen family. Explain why hydrogen is not included in either of these chemical families.
6. Copper and gold are metals that are among the very best conductors of electricity. Consider the location of copper and gold in the Periodic Table and find one more metal that is also among the best conductors of electricity.
7. Consider the following information before answering the question below: oxygen reacts 1:2 with sodium and is a colourless gas; chlorine reacts 1:1 with sodium and is a yellow gas; neon does not react with sodium and is a colourless gas. Suppose that a new element, pretendium, has been discovered, and it is noted that this element reacts 1:1 with sodium and is bright green as a gas.
   (a) Which chemical family would it belong to?
   (b) How many electrons would it have in its outermost shell?
8. Recall from Section 6.1 that there are seven elements that are found as paired atoms. In which chemical family are most of these elements found?
9. The Group number is indicated at the top of each column of the Periodic Table, from Group 1 at the left to Group 18 at the right. How many electrons are there in the outermost shell of the elements in each of the following group numbers?
   (a) 1
   (b) 2
   (c) 13
   (d) 14
   (e) 17
   (f) 18
10. The outermost shell of the Bohr diagram for an element is shown in Figure 4. In which numbered group of the Periodic Table will the element be found?

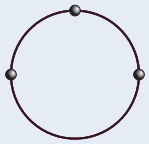

Figure 4

11. There are two instances on the Periodic Table in which the order of increasing atomic mass does not agree with the order of increasing atomic number. Which two pairs of elements are not in order of increasing atomic mass?
12. Explain why all periodic tables do not include information about all the properties of each element.