Name _____ Class _____ Date _____

CHAPTER 5 The Periodic Table

SECTION 3

Families of Elements

KEY IDEAS

As you read this section, keep these questions in mind:

- What makes up a family of elements?
- What properties do the elements in a group share?
- Why does carbon form so many compounds?

What Are Element Families?

Recall that all elements can be classified into three categories: metals, nonmetals, and semiconductors. Scientists classify the elements further into five families. The atoms of all elements in most families have the same number of valence electrons. Thus, members of a family in the periodic table share some properties. ☑

Group number	Number of valence electrons	Name of family
Group 1	1	Alkali metals
Group 2	2	Alkaline-earth metals
Groups 3–12	varied	Transition metals
Group 17	7	Halogens
Group 18	8 (except helium, which has 2)	Noble gases

READING TOOLBOX

Organize As you read this section, create a chart comparing the different families of elements. Include examples of each family and describe the common properties of elements in the family.

READING CHECK

1. Identify In general, what do all elements in the same family have in common?

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What Are the Families of Metals?

Many elements are classified as metals. Recall that metals can conduct heat and electricity. Most metals can be stretched and shaped into flat sheets or pulled into wires. Families of metals include the alkali metals, the alkaline-earth metals, and the transition metals.

THE ALKALI METALS

The elements in Group 1 form a family called the **alkali metals**. Because their atoms have only one valence electron, the alkali metals are very reactive. The valence electron can be easily removed to form a cation such as Na^+ or K^+. Alkali metals also have similar physical properties, such as melting point, boiling point, and density. ☑

READING CHECK

2. Explain Why are alkali metals so reactive?

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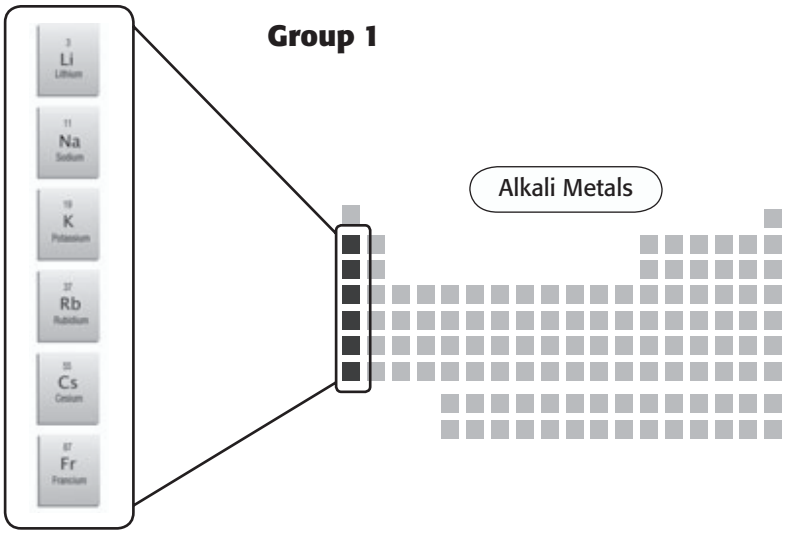

The alkali metals are found on the left edge of the periodic table.

Because alkali metals are so reactive, they are rarely found in nature as pure elements. Rather, they are found combined with other elements as compounds. For example, the alkali metal sodium is found in the salt sodium chloride, NaCl. Sodium chloride is more commonly known as table salt. ☑

READING CHECK

3. Explain Why are alkali metals rarely found as pure elements?

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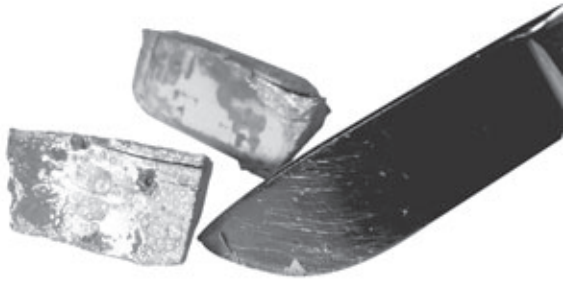

Alkali metals, such as sodium, are so soft that they can be cut with a knife.

THE ALKALINE-EARTH METALS

The elements in Group 2 form a family called the **alkaline-earth metals**. The atoms of alkaline-earth metals have two valence electrons. These elements are reactive, but not as reactive as alkali metals. ☑

READING CHECK

4. Describe Describe the reactivity of alkaline-earth metals.

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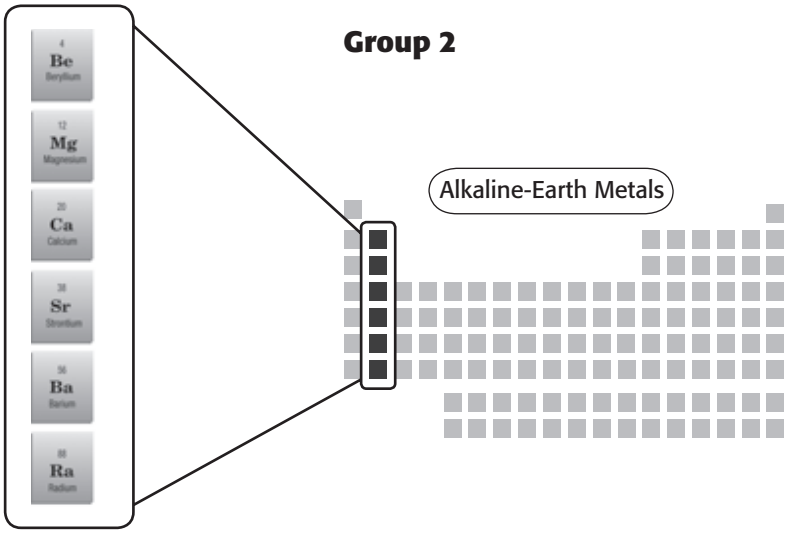

The alkaline-earth metals are found in Group 2 in the periodic table.

Alkaline-earth metals form cations with 2^+ charges, such as Mg^{2+} and Ca^{2+}. The alkaline-earth metals combine with other elements to form compounds. For example, two magnesium compounds—milk of magnesia and Epsom salts—are commonly used to treat minor medical problems. In addition, many calcium compounds are important to living things. Some make up the hard shells of many sea animals. Calcium compounds also make your bones and teeth strong.

Critical Thinking

5. Apply Concepts Do alkaline-earth elements gain electrons or lose electrons to form ions?

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The stalagmites and stalactites in limestone caves contain calcium carbonate deposits.

THE TRANSITION METALS

An element located in Groups 3-12 is known as a **transition metal**. Transition metals are not as reactive as the alkali metals or the alkaline-earth metals. In fact, some transition metals are quite unreactive. ☑

READING CHECK

6. Describe Describe the reactivity of transition metals.

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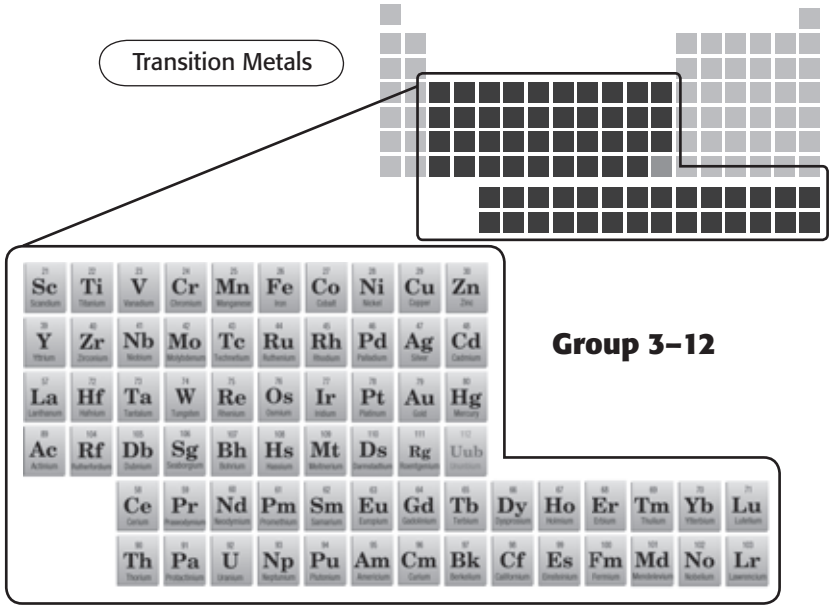

The transition metals are located in the middle of the periodic table.

LOOKING CLOSER

7. Identify Where are the transition metals located on the periodic table?

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Although they are generally unreactive, transition metals can form ions. For example, an atom of gold, Au, can lose one electron to form Au^{+} or three electrons to form Au^{3+}. Some transition metals can form as many as four different ions. Why? Transition metals have complex arrangements of electrons that make them behave differently than other elements. ☑

READING CHECK

8. Explain Why can transition metals form different kinds of ions?

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Both gold and platinum are shaped to make jewelry.

Like other metals, the transition metals are good conductors of electricity and heat. Most transition metals are harder, denser, and have higher melting points than alkali and alkaline-earth metals. Mercury is an exception. Mercury is the only metal that is a liquid at room temperature. For this reason, mercury is used in some thermometers.

SYNTHETIC ELEMENTS

All elements with atomic numbers greater than 92 are *synthetic*, or made in a laboratory. Technetium and promethium have atomic numbers lower than 92, but they are also synthetic elements. Synthetic elements are radioactive. Radioactive elements decay, or break down. They may become different elements. ☑

Examine the periodic table in the back of the book. Note that parts of Periods 6 and 7 are placed in two rows at the bottom of the periodic table. Many of these elements are synthetic. These two rows are placed separately so that the rest of the periodic table stays narrow. This placement also allows the other elements to line up according to periodic trends.

Synthetic elements have various uses. Plutonium is used to make nuclear weapons. Americium is used in smoke detectors.

READING CHECK

9. Define What are synthetic elements?

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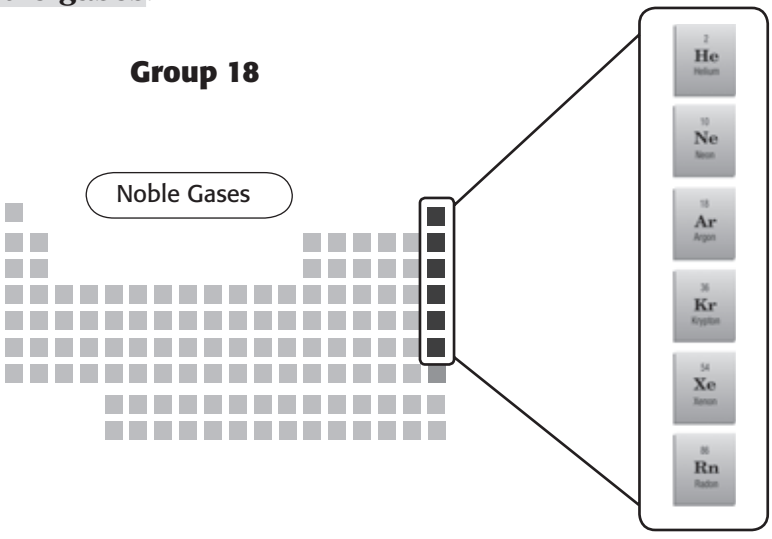
What Are the Families of Nonmetals?

Except for hydrogen, nonmetals are located on the right side of the periodic table. Nonmetals include some elements in Groups 13–16 and all the elements in Groups 17 and 18. Families of nonmetals include the noble gases and the halogens.

THE NOBLE GASES

The elements in Group 18 form a family called the **noble gases**.



The noble gases are located along the right edge of the periodic table.

LOOKING CLOSER

10. Infer How many valence electrons do noble gases have? Explain your answer.

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Neon produces the bright reddish orange light in neon signs. Other gases are added to make different colors.

Unlike most elements, the noble gases exist as single atoms, rather than as molecules or ions. Why? The outermost energy level of a noble gas atom is filled. Thus, noble gases are *inert*, or unreactive, and they do not typically react with other elements to form compounds. In other words, noble gases are very stable. ☑

Because noble gases are inert, they can be useful in many situations. For example, light bulbs are filled with argon gas because argon will not react with the bulb's metal filament.

READING CHECK

11. Explain Why do noble gases exist as single atoms rather than as compounds?

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THE HALOGENS

The elements in Group 17 form a family called the **halogens**. The halogens are the most reactive nonmetals. They are very reactive because each atom has seven valence electrons. If it gains one electron, a halogen atom becomes stable.

Halogens combine easily with alkali metals because atoms of alkali metals need to lose one valence electron to become stable. Halogens can also combine with other metals. These combinations are called salts.

Some examples of common uses of halogens are described below.

- A compound containing the fluoride ion, F^-, is added to many toothpastes and water supplies. Fluoride helps prevent tooth decay.
- A compound containing the iodide ion, I^-, is added to table salt to make iodized salt. You need iodine in your diet to help you stay healthy.
- A compound containing chlorine is added to swimming pool and drinking-water supplies. Chlorine can kill bacteria.

Critical Thinking

12. Infer Why do Na and Cl readily combine to form a compound?

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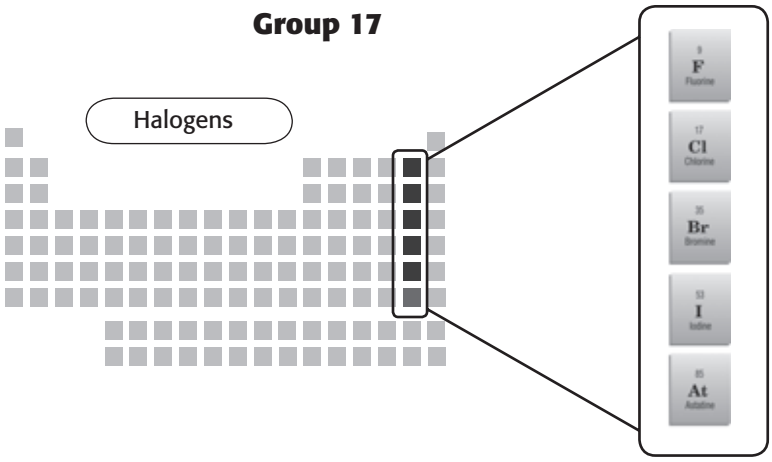

Halogens are located in the second column from the right on the periodic table.

HYDROGEN—A UNIQUE ELEMENT

Although hydrogen has one valence electron, it is not a member of the alkali metal family. Hydrogen has only one proton and one electron and has different properties from other Group 1 elements. ☑

Hydrogen is the most abundant element in the universe. About three out of every four atoms in the universe are hydrogen atoms. Most of these are located in clouds of gas and stars.

With only one electron, hydrogen can react with many other elements. For example, hydrogen reacts with oxygen to form water, H_2O, which is essential to life.

READING CHECK

13. Explain Why is hydrogen not considered an alkali metal?

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What Are the Semiconductors?

Recall that semiconductors can conduct electricity under certain conditions. The family of semiconductors contains six elements. These elements are not found in one particular group. Instead, they are found in different periods and groups. ☑

READING CHECK

14. Describe What are semiconductors?

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LOOKING CLOSER

15. Describe How does the location of semiconductors on the periodic table differ from the locations of other element families?

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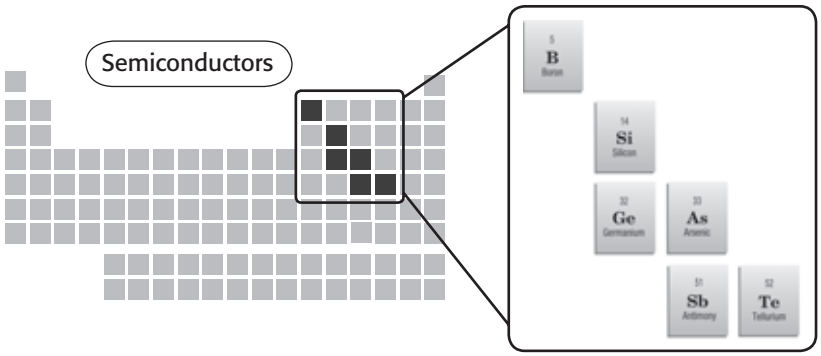

Unlike other families of elements, semiconductors are not found in one group or in a block of groups. They are scattered among several periods and groups.

OTHER NONMETALS

In addition to the noble gases and halogens, there are six other nonmetals. Oxygen, nitrogen, and sulfur are very common nonmetals. They may gain electrons to form ions. For example, oxygen can form oxide, O^{2-}, nitrogen can form nitride, N^{3-}, and sulfur can form sulfide, S^{2-}.

Nitrogen and oxygen are the most plentiful gases in air. Sulfur is an odorless solid. However, many sulfur compounds, such as those in rotten eggs and skunk spray, have a terrible smell.

Critical Thinking

16. Apply Concepts How many electrons does an oxygen atom gain to form an oxide ion?

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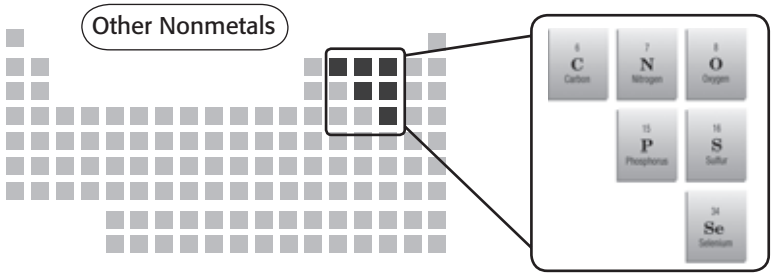
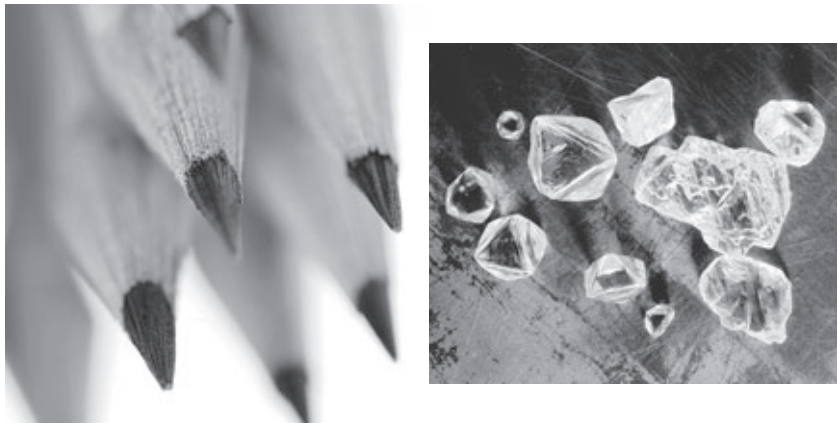


The remaining nonmetals are carbon, nitrogen, oxygen, phosphorus, sulfur, and selenium.



Graphite and diamond are both forms of carbon.

Carbon atoms can combine with one another in different ways to produce very different compounds. One way carbon atoms combine with one another produces graphite, which is used in pencil "lead." Carbon atoms can combine in another way to form diamonds.

Carbon atoms can also combine to form substances called *fullerenes*. The most famous has 60 carbon atoms and is known as *buckminsterfullerene*. The structure of this substance looks like a geodesic dome that was designed by American inventor R. Buckminster Fuller. A geodesic dome is a structure that looks like a large soccer ball.

Carbon can also combine with other elements to form millions of different compounds. These carbon-containing compounds are found in both living and nonliving things. Carbon compounds found in living things include sugars that you eat and chlorophyll in the cells of plants. Carbon compounds in nonliving things include rubber and isooctane in gasoline.

Critical Thinking

17. Explain Why is it not correct to refer to the material in pencils as "lead"?

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Name _____ Class _____ Date _____

Section 3 Review

SECTION VOCABULARY

alkali metal one of the elements of Group 1 of the periodic table (lithium, sodium, potassium, rubidium, cesium, and francium)

alkaline-earth metal one of the elements of Group 2 of the periodic table (beryllium, magnesium, calcium, strontium, barium, and radium)

halogen one of the elements of Group 17 of the periodic table (fluorine, chlorine, bromine, iodine, and astatine); halogens combine with most metals to form salts

noble gas one of the elements of Group 18 of the periodic table (helium, neon, argon, krypton, xenon, and radon); noble gases are unreactive

transition metal one of the metals that can use the inner shell before using the outer shell to bond

1. Identify Which element is more reactive—lithium, Li, or beryllium, Be? Explain your answer.

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2. Infer Scientists store some reactive chemicals in containers filled with argon. Why?

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3. Classify Complete the following table to describe several elements. Use the periodic table in the back of the book to help you.

Symbol	Group number	Period number	Family name
Co			
		Period 2	semiconductor
		Period 6	halogen
Mg	Group 2		
		Period 5	noble gas

4. Infer A particular substance is typically found in nature as a pure element. What can you conclude about the reactivity of this element? (Hint: Which family contains elements that are generally found as pure elements?)

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