Section 3

Metals

Reading Preview

Key Concepts

- What are the physical properties of metals?
- How does the reactivity of metals change across the periodic table?
- How are elements that follow uranium in the periodic table produced?

Key Terms

- metal • malleable • ductile
- conductivity • reactivity
- corrosion
- alkali metal
- alkaline earth metal
- transition metal • alloy
- particle accelerator

Target Reading Skill

Using Prior Knowledge Before you read, write what you know about metals in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Metals are shiny. 2.

What You Learned
1. 2.

Lab zone Discover Activity

Why Use Aluminum?

1. Examine several objects made from aluminum, including a can, a disposable pie plate, heavy-duty aluminum foil, foil-covered wrapping paper, and aluminum wire.
2. Compare the shape, thickness, and general appearance of the objects.
3. Observe what happens if you try to bend and unbend each object.
4. For what purpose is each object used?

Think It Over

Inferring Use your observations to list as many properties of aluminum as you can. Based on your list of properties, infer why aluminum was used to make each object. Explain your answer.

Metals are all around you. The cars and buses you ride in are made of steel, which is mostly iron. Airplanes are covered in aluminum. A penny is made of zinc coated with copper. Copper wires carry electricity into lamps, stereos, and computers. It's hard to imagine modern life without metals.

Properties of Metals

What is a metal? Take a moment to describe a familiar metal, such as iron, copper, gold, or silver. What words did you use—*hard, shiny, smooth*? Chemists classify an element as a **metal** based on its properties. Look again at the periodic table in Section 2. All of the elements in blue-tinted squares to the left of the zigzag line are metals.

Physical Properties **The physical properties of metals include shininess, malleability, ductility, and conductivity.** A **malleable** (MAL ee uh bul) material is one that can be hammered or rolled into flat sheets and other shapes. A **ductile** material is one that can be pulled out, or drawn, into a long wire. For example, copper can be made into thin sheets and wire because it is malleable and ductile.

Conductivity is the ability of an object to transfer heat or electricity to another object. Most metals are good conductors. In addition, a few metals are magnetic. For example, iron (Fe), cobalt (Co), and nickel (Ni) are attracted to magnets and can be made into magnets like the one in Figure 12. Most metals are also solids at room temperature. However, one metal—mercury (Hg)—is a liquid at room temperature.

Chemical Properties The ease and speed with which an element combines, or reacts, with other elements and compounds is called its **reactivity.** Metals usually react by losing electrons to other atoms. Some metals are very reactive. For example, sodium (Na) reacts strongly when exposed to air or water. To prevent a reaction, sodium and metals like it must be stored under oil in sealed containers. By comparison, gold (Au) and platinum (Pt) are valued for their *lack* of reactivity and because they are rare.

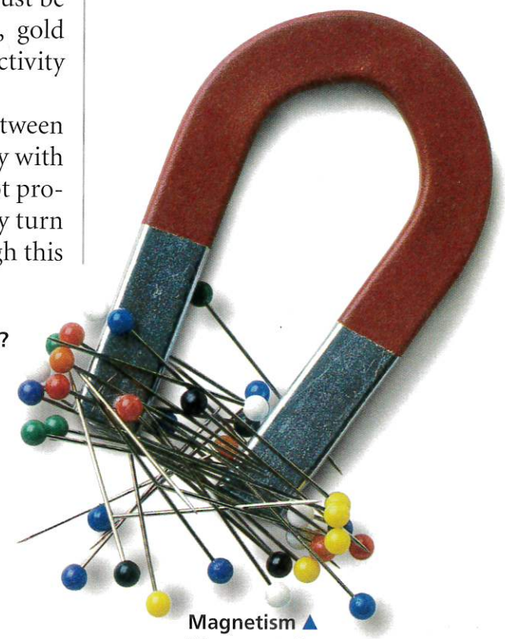
The reactivities of other metals fall somewhere between those of sodium and gold. Iron, for example, reacts slowly with oxygen in the air, forming iron oxide, or rust. If iron is not protected by paint or plated with another metal, it will slowly turn to reddish-brown rust. The destruction of a metal through this process is called **corrosion.**

Reading Checkpoint What are three physical properties of metals?

FIGURE 12

Properties of Metals

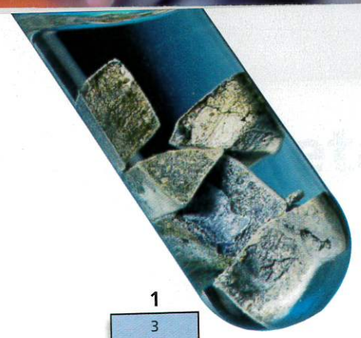
Metals have certain physical and chemical properties.
Classifying *Categorize each of the properties of metals that are shown as either physical or chemical.*



Magnetism ▲
Many metals are attracted to magnets.

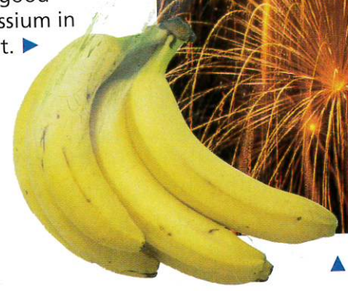
▼ Malleability
Gold can be pounded into coins.

Reactivity ▶
This iron chain is coated with rust after being exposed to air.

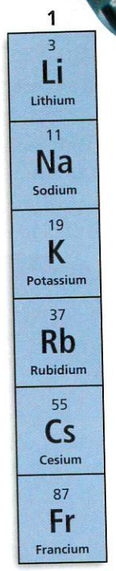


◀ Potassium is highly reactive with air, so it is stored in oil.

Bananas are a good source of potassium in a healthful diet. ▶



▲ The reactions of some compounds containing potassium help get fireworks off the ground.



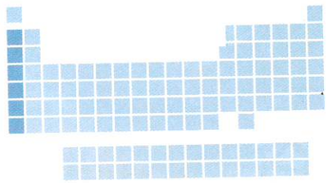


FIGURE 13
Alkali Metals
Potassium is an alkali metal.
Making Generalizations *What characteristics do other Group 1 elements share with potassium?*

Metals in the Periodic Table

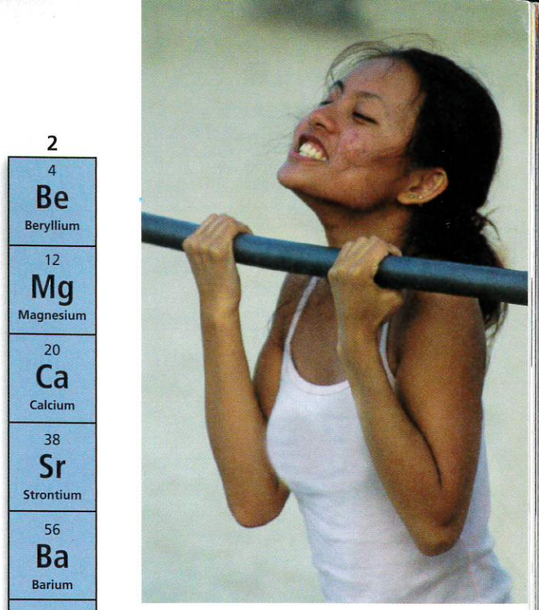
The metals in a group, or family, have similar properties, and these family properties change gradually as you move across the table. **The reactivity of metals tends to decrease as you move from left to right across the periodic table.**

Alkali Metals The metals in Group 1, from lithium to francium, are called the **alkali metals.** Alkali metals react with other elements by losing one electron. These metals are so reactive that they are never found as uncombined elements in nature. Instead, they are found only in compounds. In the laboratory, scientists have been able to isolate alkali metals from their compounds. As pure, uncombined elements, some of the alkali metals are shiny and so soft that you can cut them with a plastic knife. You can see pieces of potassium in Figure 13.

The two most important alkali metals are sodium and potassium. Sodium compounds are found in large amounts in seawater and salt beds. Your diet includes foods that contain compounds of sodium and potassium, elements important for life. Another alkali metal, lithium, is used in batteries and some medicines.

Alkaline Earth Metals Group 2 of the periodic table contains the **alkaline earth metals.** Each is fairly hard, gray-white, and a good conductor of electricity. Alkaline earth metals react by losing two electrons. These elements are not as reactive as the metals in Group 1, but they are more reactive than most other metals. Like the Group 1 metals, the Group 2 metals are never found uncombined in nature.

The two most common alkaline earth metals are magnesium and calcium. Mixing magnesium and a small amount of aluminum makes a strong but lightweight material used in ladders, airplane parts, automobile wheels, and other products. Calcium compounds are an essential part of teeth and bones. Calcium also helps muscles work properly. You get calcium compounds from milk and other dairy products, as well as from green, leafy vegetables.



▲ Without calcium, muscles and bones cannot grow and function.

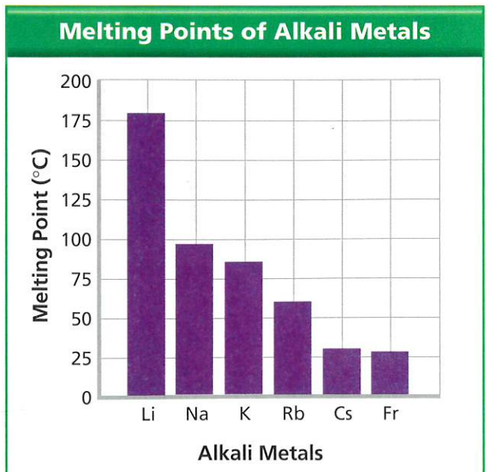
FIGURE 14
Alkaline Earth Metals
Calcium is one of the Group 2 elements.

Math Analyzing Data

Melting Points in a Group of Elements

The properties of elements within a single group in the periodic table often vary in a certain pattern. The following graph shows the melting points of Group 1 elements (alkali metals) from lithium to francium.

1. **Reading Graphs** As you look at Group 1 from lithium to francium, describe how the melting points of the alkali metals change.
2. **Predicting** If element number 119 were synthesized, it would fall below francium in Group 1 of the periodic table. Predict the approximate melting point of new element 119.
3. **Interpreting Data** Room temperature is usually about 22°C. Human body temperature is 37°C. Which of the alkali metals are liquids at room temperature? Which might melt if you could hold them in your hand?



Transition Metals The elements in Groups 3 through 12 are called the **transition metals.** The transition metals include most of the familiar metals, such as iron, copper, nickel, silver, and gold. Most of the transition metals are hard and shiny. All of the transition metals are good conductors of electricity. Many of these metals form colorful compounds.

The transition metals are less reactive than the metals in Groups 1 and 2. This lack of reactivity is the reason ancient gold coins and jewelry are as beautiful and detailed today as they were thousands of years ago. Even when iron reacts with air and water, forming rust, it sometimes takes many years to react completely. Some transition metals are important to your health. For example, you would not survive without iron. It forms the core of a large molecule called hemoglobin, which carries oxygen in your bloodstream.

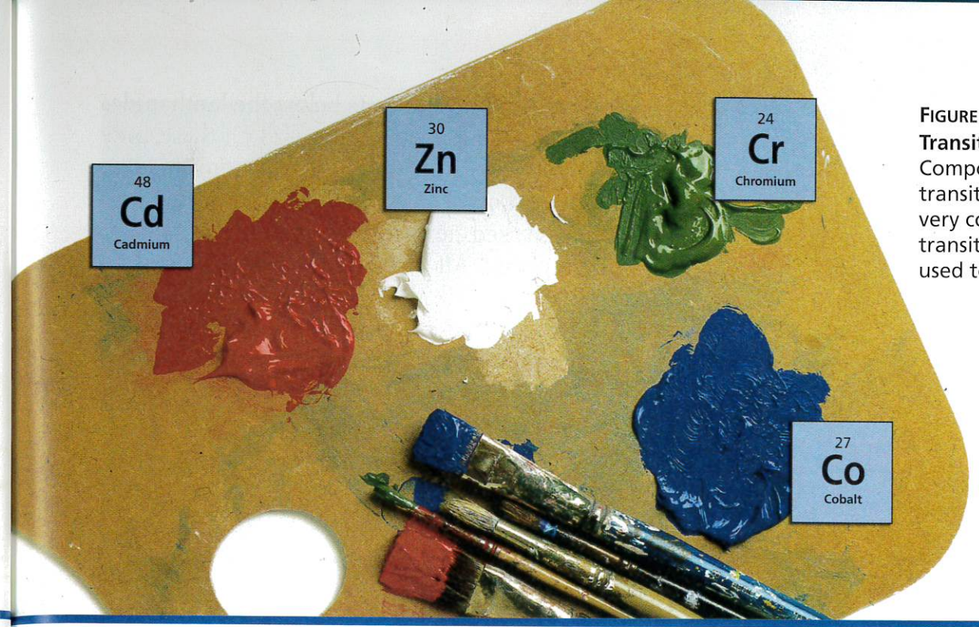


FIGURE 15
Transition Metals
Compounds made with transition metals can be very colorful. Several transition metals are used to make paints.

Metals in Mixed Groups Only some of the elements in Groups 13 through 15 of the periodic table are metals. These metals are not nearly as reactive as those on the left side of the table. The most familiar of these metals are aluminum, tin, and lead. Aluminum is the lightweight metal used in beverage cans and airplane bodies. A thin coating of tin protects steel from corrosion in some cans of food. Lead was once used in paints and water pipes. But lead is poisonous, so it is no longer used for these purposes. Now, its most common uses are in automobile batteries and weights for balancing tires.

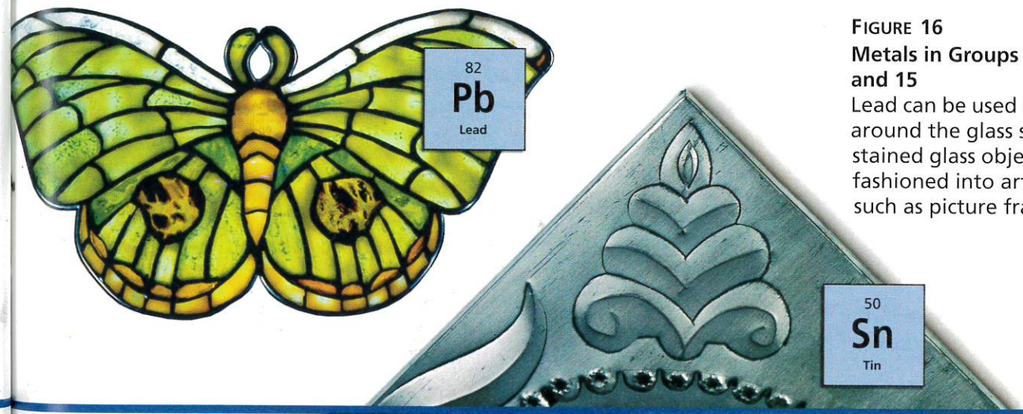


FIGURE 16
Metals in Groups 13, 14, and 15
Lead can be used in the borders around the glass sections in stained glass objects. Tin can be fashioned into artistic objects, such as picture frames.

Lanthanides Two rows of elements are placed below the main part of the periodic table. This makes the table more compact. The elements in the top row are called the lanthanides (LAN thuh nydz). Lanthanides are soft, malleable, shiny metals with high conductivity. They are mixed with more common metals to make alloys. An **alloy** is a mixture of a metal with at least one other element, usually another metal. Different lanthanides are usually found together in nature. They are difficult to separate from one another because they all share very similar properties.

FIGURE 17
Lanthanides
Neodymium is used in manufacturing the tiny speakers inside stereo headphones.

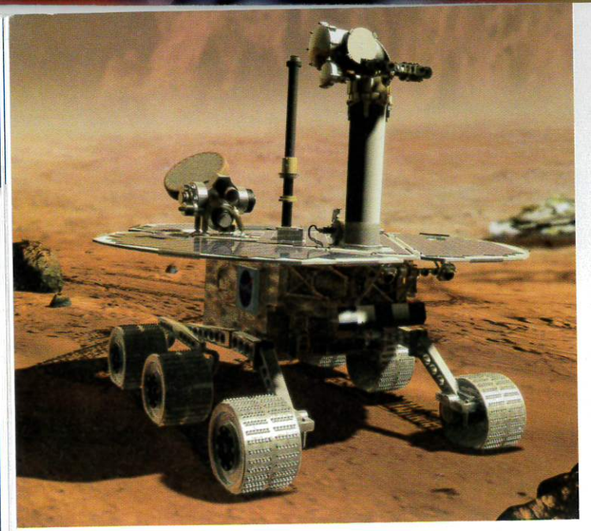


FIGURE 18
Mars Exploration Rover
Curium, one of the actinide elements, is used as a source of high-energy particles that heat and provide power for certain scientific equipment aboard the Mars Exploration Rover.
Posing Questions *Based on this information, write a question about curium.*

Actinides The elements below the lanthanides are called actinides (AK tuh nydz). Of these, only actinium (Ac), thorium (Th), protactinium (Pa), and uranium (U) occur naturally on Earth. Uranium is used to produce energy in nuclear power plants. All of the elements heavier than uranium were created artificially in laboratories. The nuclei of these elements are unstable, meaning that they break apart quickly into smaller nuclei. In fact, many of these elements are so unstable that they last for only a fraction of a second after they are made.

Reading Checkpoint **Where are the actinides located in the periodic table?**

Synthetic Elements

Elements with atomic numbers higher than 92 are sometimes described as synthetic elements because they are not found naturally on Earth. **Instead, elements that follow uranium are made—or synthesized—when nuclear particles are forced to crash into one another.** For example, plutonium is made by bombarding nuclei of uranium-238 with neutrons in a nuclear reactor. Americium-241 (Am-241) is made by bombarding plutonium nuclei with neutrons.

To make even heavier elements (with atomic numbers above 95), scientists use powerful machines called particle accelerators. **Particle accelerators** move atomic nuclei faster and faster until they have reached very high speeds. If these fast-moving nuclei crash into the nuclei of other elements with enough energy, the particles can sometimes combine into a single nucleus. Curium (Cm) was the first synthetic element to be made by colliding nuclei. In 1940, scientists in Chicago synthesized curium by colliding helium nuclei with plutonium nuclei.

In general, the difficulty of synthesizing new elements increases with atomic number. So, new elements have been synthesized only as more powerful particle accelerators have been built. For example, German scientists synthesized element 112 in 1996 by accelerating zinc nuclei and crashing them into lead. Element 112, like other elements with three-letter symbols, has been given a temporary name and symbol. In the future, scientists around the world will agree on permanent names and symbols for these elements.

Reading Checkpoint **Which elements are described as synthetic elements and why?**

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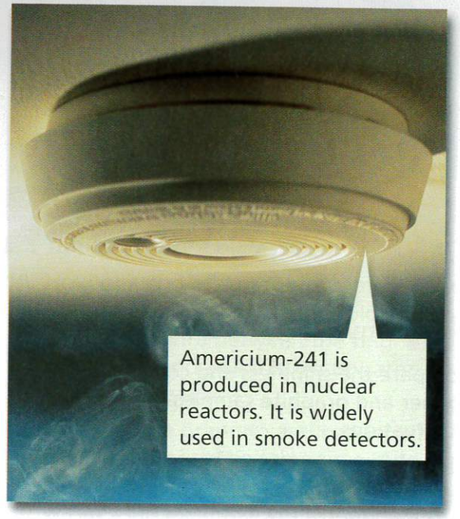

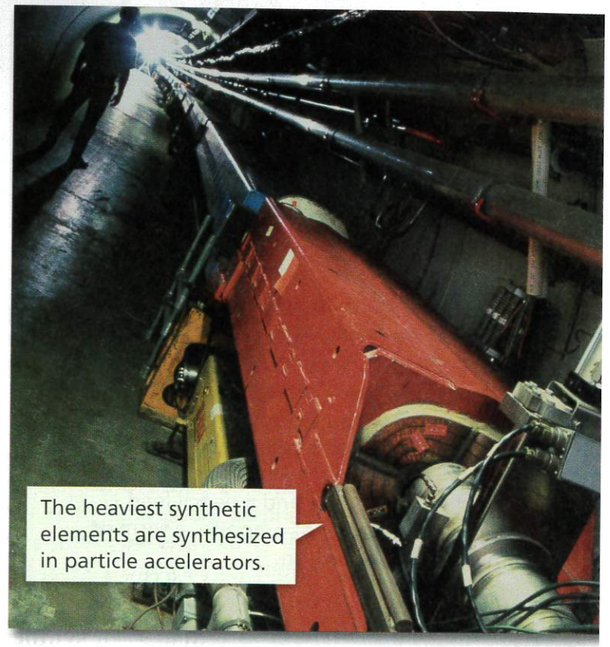

FIGURE 19
Synthetic Elements
Synthetic elements are not found naturally on Earth.

Section 3 Assessment

Target Reading Skill **Using Prior Knowledge** Review your graphic organizer about metals and revise it based on what you learned in the section.

Reviewing Key Concepts

1. a. **Defining** What properties of metals do the terms *conductivity* and *ductility* describe?
   b. **Classifying** Give an example of how the ductility of metal can be useful.
   c. **Inferring** What property of metals led to the use of plastic or wood handles on many metal cooking utensils? Explain.
2. a. **Identifying** What family of elements in the periodic table contains the most reactive metals?
   b. **Applying Concepts** What area of the periodic table is the best place to look for a metal that could be used to coat another metal to protect it from corrosion?
   c. **Predicting** If scientists could produce element 120, what predictions would you make about its reactivity?
3. a. **Describing** Describe the general process by which new elements are synthesized.
   b. **Applying Concepts** How is plutonium made?

Lab zone At-Home Activity

Everyday Metals Make a survey of compounds in your home that contain metals. Look at labels on foods, cooking ingredients, dietary supplements, medicines, and cosmetics. Also look for examples of how metals are used in your home, such as in cookware and wiring. Identify for your family the ways that the properties of metals make them useful in daily life.