3 Metals

Objectives

After this lesson, students will be able to

K.3.3.1 List the physical properties of metals.

K.3.3.2 Explain how the reactivity of metals changes across the periodic table.

K.3.3.3 Explain how the elements that follow uranium are produced.

Target Reading Skill

Using Prior Knowledge Explain that using prior knowledge helps students connect what they already know to what they are about to read.

Answers

Sample answers:

What You Know

1. Metals are shiny.
2. Some metals are magnetic.

What You Learned

1. Ductile metals can be pulled into a wire.
2. Alkali metals react by losing one electron.

All in One Teaching Resources

- Transparency K26

Preteach

Build Background Knowledge

L2

Observing Properties of Metals

Display various objects made of metal such as coins, wire, paper clips, toy cars, foil, jewelry, scissors, nails, and cookware. Invite students to observe the objects and, as a class, develop a list of physical properties of metals. Revise this list after completing the section.

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.

Lab zone Discover Activity

Skills Focus Inferring L1

Materials aluminum can, disposable pie plate, heavy-duty foil, foil-covered wrapping paper, aluminum wire

Time 10 minutes

Tips Suggest students make charts of their observations and inferences.

Expected Outcome Students will observe that aluminum is lightweight, flexible, and shiny; holds liquids; can conduct heat; and can be rolled into sheets and pulled into wires.

Think It Over Sample answer: Properties of aluminum are shininess, hardness, able to bend, and conductor of heat and electricity. Students should match the function of each object they examined with at least one property of aluminum.

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?**

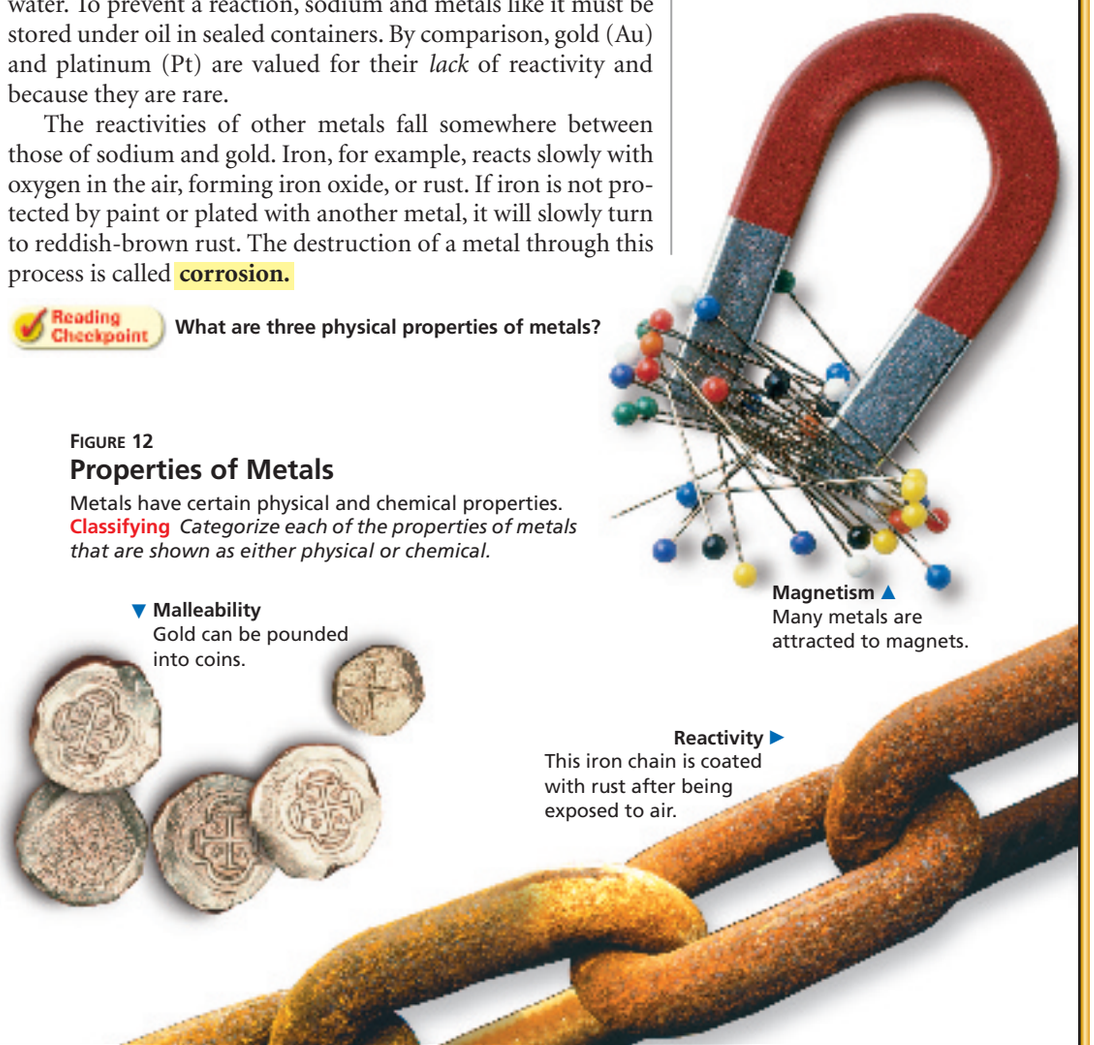


FIGURE 12
Properties of Metals
Metals have certain physical and chemical properties.
Classifying *Categorize each of the properties of metals that are shown as either physical or chemical.*

Differentiated Instruction

Special Needs L1
Classifying Metals Have students classify a wide variety of objects as metals or not metals. Consider providing instruments such as a magnet and a simple electrical conductivity tester. Discuss the criteria students used to classify the objects and relate them to the physical properties described in this section. **learning modality: kinesthetic**

Special Needs L1
Experiencing Properties Provide tactile experiences for students to learn the meanings of the words *malleable* and *ductile*. Students can pound modeling clay into shapes to experience malleability. They can pull modeling clay into a thin strand to experience ductility. **learning modality: kinesthetic**

Instruct

Properties of Metals

Teach Key Concepts L2

Properties of Metals

Focus Show students the location of metals in the periodic table.

Teach Explain that elements are classified as metals based on their properties. Ask: **What are some physical properties of metals?** *(Shininess, malleability, ductility, conductivity, and magnetism.)*

Apply Tell students that not every metal has all of these physical properties. Ask: **Which metal is not a solid at room temperature?** *(Mercury)* **learning modality: verbal**

Help Students Read L1

Anticipation Guide Refer to the Content Refresher in this chapter, which provides guidelines for using this strategy.

Ask students which statements are true: **1.** A malleable material can be pounded into shapes. *(True)* **2.** Most metals react with atoms of other elements by losing electrons. *(True)* **3.** The reactivity of metals tends to increase from left to right across the periodic table. *(False)* **4.** Elements heavier than uranium are not found in nature. *(True)*

After students read the section, revisit these questions.

Independent Practice L2

All in One **Teaching Resources**

- Guided Reading and Study Worksheet: *Metals*

Student Edition on Audio CD

Monitor Progress L2

Skills Check Have students make a concept map that classifies the properties of metals as physical or chemical.

Students can save their concept maps in their portfolios. Portfolio

Answers

Figure 12 Physical: magnetism and malleability; chemical: reactivity

Reading Checkpoint Physical properties include shininess, malleability, ductility, conductivity, and magnetism.

Metals in the Periodic Table

Teach Key Concepts L2

Characterizing Metal Groups

Focus Tell students that elements in the same group have similar properties and group properties change gradually across the periodic table.

Teach Begin a table on the board with the names of each metal group at the top. As you study each group, record the properties of that group, including the number of electrons lost when reacting with other elements. Also include examples of each. Ask: **How do these group properties change as you move across the table?** *(The reactivity of metals tends to decrease from left to right across the table.)*

Apply Ask: **Is reactivity a chemical or physical property?** *(Chemical property)* Explain that the number of electrons lost determines the reactivity of a metal. **learning modality: visual**

Lab zone Teacher Demo

Differentiating Alkali Metals L2

Materials Gas burner, hydrochloric acid (1*M* HCl), lithium chloride, matches, nichrome wire loop, potassium iodide, sodium chloride

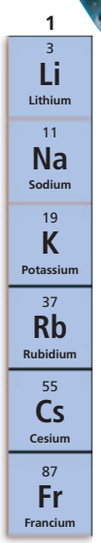
Time 15 minutes

Focus Explain that scientists can identify certain metals with a flame test because they produce distinctive colors when heated in a flame.

Teach Dip the metal probe in one of the metal samples. Place the probe in the burner flame. Invite students to describe the color of the flame. Before testing another metal, clean the probe by dipping it in hydrochloric acid and heating it in the flame until the flame is not colored. Make sure students observe a different colored flame from each sample. (Sodium: yellow; potassium: purple; lithium: red)

Apply Explain that the yellow produced by sodium can be seen in sodium vapor lights, such as those used in parking lots and stadiums. These colors are also used to color fireworks and flares. **learning modality: visual**

◀ 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.

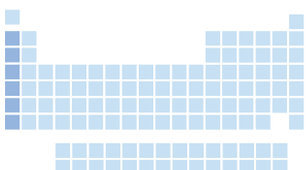


FIGURE 13
Alkali Metals
Potassium is an alkali metal.
Making Generalizations *What characteristics do other Group 1 elements share with potassium?*

Metals in the Periodic Table

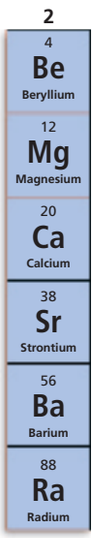
The metals in a group, or family, have similar properties, and these family properties change gradually as you move across the table. **The reactivity of metals tends to decrease as you move from left to right across the periodic table.**

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.



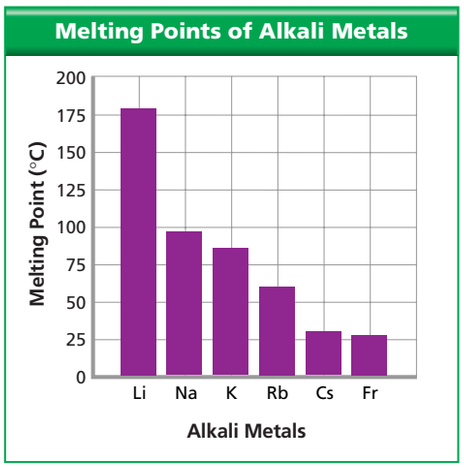
▲ Without calcium, muscles and bones cannot grow and function.

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?

Integrating Life Science L2

Identifying Metals Essential for Life

Focus Tell students that some of the nutrients they need for good health are metals.

Teach Give students Nutrition Facts labels from various food products. (Fortified cereals often have the most complete labels.) Instruct students to read the labels and make a list of metals that are named. *(Students may find sodium, potassium, calcium, iron, phosphorus, magnesium, zinc, and copper.)* Then have students identify the family in which each element belongs. *(Alkali metals: sodium and potassium; alkaline earth metals: magnesium and calcium; transition metals: iron, zinc, and copper; phosphorous is a nonmetal)*

Apply Point out that the other nutrients and vitamins listed in the Nutrition Facts are made up of combinations of elements, or compounds. Ask: **What is the importance of metals to the body?** *(Without certain metal elements, the body cannot grow or work properly.)* **learning modality: logical/mathematical**

Math Analyzing Data

Math Skill Making and interpreting graphs

Focus Tell students that melting point is a physical property.

Answers

1. Melting points decrease from lithium to francium.

2. New element 119 should have a melting point of approximately 25°C or lower.

3. None of the alkali metals are liquids at room temperature. Cesium and francium might melt if you could hold them in your hand.

All in One Teaching Resources

- Transparency K27

Differentiated Instruction

Less Proficient Readers L1

Comparing and Contrasting Give students a blank compare/contrast table to complete as they read about the metals in the periodic table. Use the names of the groups of metals as column headings. For row headings, use physical and chemical properties such as number of electrons lost when reacting with other elements, reactivity, shininess, conductivity, and magnetic attraction. Also have a space in which students can record examples of elements from each group. After students have read the section and completed the table, ask them to write a summary sentence to describe the characteristics of each metal group. Students should write sentences that use information gathered in their tables. **learning modality: verbal**

Monitor Progress L2

Writing Instruct students to write a sentence to explain how alkali metals and alkaline earth metals react with other elements.

Answer

Figure 13 They react by losing one electron, are found in nature only in compounds, and are shiny and soft.

Help Students Read L2

Building Vocabulary: Word Origin

Challenge students to explain the meaning of the word *transition* in their own words. Point out that the word *transition* comes from the Latin word *transire,* which means "to go across." Encourage students to speculate about how the name *transition metals* is appropriate. *(A bridge "goes across" something, and the transition metals act as a bridge between the very reactive metals on the left side of the table and the less reactive metals and other elements on the right side.)*

Lab zone Build Inquiry L2

Classifying Metals

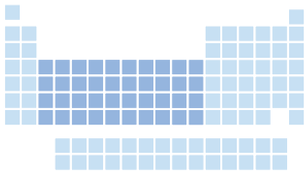
Materials index cards

Time 15 minutes

Focus Remind students that metals in the same group, or family, have similar properties.

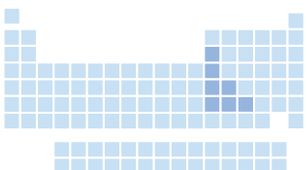
Teach Have student groups write a property or a use of a metal group on an index card. Each group should write at least ten different cards. Groups can exchange cards and classify the cards into the metal groups based on the property or use.

Extend Challenge students to arrange their groups of cards in order from most reactive to least. **learning modality: logical/mathematical**

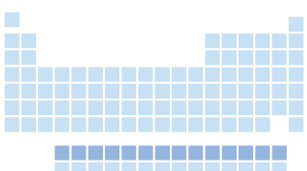


Transition Metals The elements in Groups 3 through 12 are called the **transition metals.** The transition metals include most of the familiar metals, such as iron, copper, nickel, silver, and gold. Most of the transition metals are hard and shiny. All of the transition metals are good conductors of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



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.



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.

Differentiated Instruction

Gifted and Talented L3

Recycling Metals Challenge students to consider whether metals are renewable or nonrenewable resources. *(They are nonrenewable; metal resources cannot be replaced once they are used.)* Have students find out if metal resources can be sustainable (made, used, and disposed of in a way that allows them to be reused over and over again). Encourage students to investigate metal recycling in your area. Have them find out why companies are paying more and more for scrap metal. Suggest that they start a recycling program at your school or town if one does not exist. **learning modality: logical/mathematical**

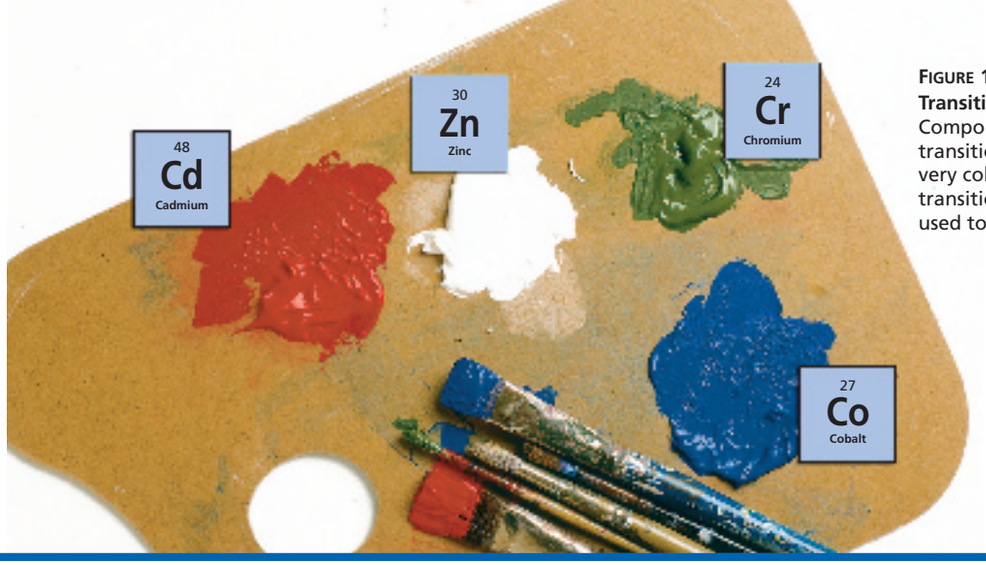


FIGURE 15
Transition Metals
Compounds made with transition metals can be very colorful. Several transition metals are used to make paints.

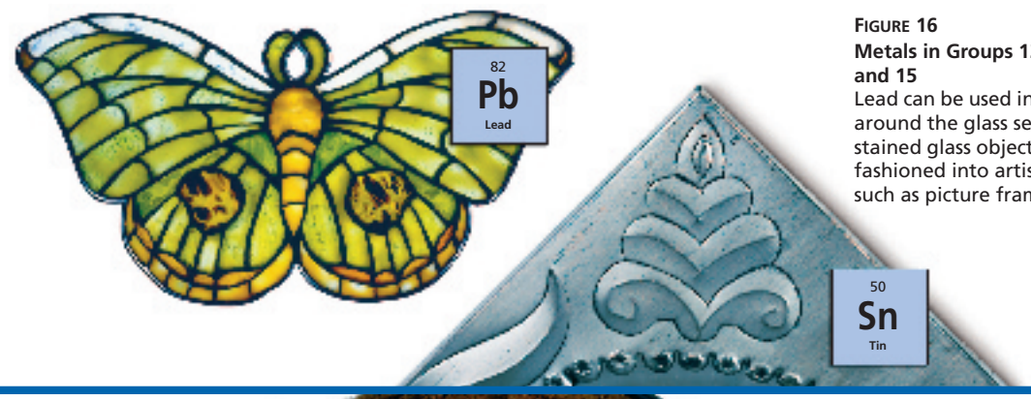


FIGURE 16
Metals in Groups 13, 14, and 15
Lead can be used in the borders around the glass sections in stained glass objects. Tin can be fashioned into artistic objects, such as picture frames.

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

Lab zone **Build Inquiry** L2

Finding Metals

Materials none

Time 15 minutes

Focus Point out that metals are found and used everywhere.

Teach Have students go on a metal "scavenger hunt." Give them the opportunity to examine themselves, the classroom, and the school building and grounds for examples of metals. Students should compile a list of metals they observe and how the metals are being used. When they return to their desks, have groups share their observations. Make a class list of metals observed. Then challenge students to identify the metals.

Apply Ask: **How is the use of the metal related to its reactivity?** *(Sample answer: Metals used outdoors or as jewelry are less reactive.)* **learning modality: kinesthetic**

Monitor Progress L2

Oral Presentation Have students choose a family of metals and use the periodic table to name all the metals in that group.

Synthetic Elements

Teach Key Concepts L2

Some Elements Do Not Occur Naturally

Focus Tell students that not all elements are found naturally on Earth.

Teach Ask: **How do scientists make elements that are heavier than uranium?** *(By forcing nuclear particles to crash into one another)* **How does a particle accelerator work?** *(It moves atomic nuclei faster and faster until they have enough energy to crash into the nuclei of other elements and combine to form a single, larger nucleus.)*

Apply Illustrate this idea on the board by diagramming the nucleus of a helium atom and the nucleus of a plutonium atom colliding to form curium. Ask: **How many protons does helium have?** *(Two)* **Plutonium?** *(94)* **Curium?** *(96)* **learning modality: visual**

Lab zone Build Inquiry L2

Modeling a Particle Accelerator

Materials small round magnets, steel balls bearings

Time 15 minutes

Focus Remind students how a particle accelerator works.

Teach Instruct students to place as many metal balls on the magnet as they can. Ask: **How many metal balls can you place on the magnet before they begin to fall off?** (Answers depend on the size of the magnet and the size of the balls.) Explain that the metal balls model the protons in the nucleus of an atom. Ask: **If the magnet represents energy, how could you get a larger nucleus?** *(By adding another magnet)*

Apply Ask: **Why do you think these elements are not found naturally on Earth?** *(Sample answer: The atoms are so large that they are not stable.)* **learning modality: kinesthetic**

Go Online NSTA SciLinks

For: Links on metals
Visit: www.SciLinks.org
Web Code: scn-1133

Download a worksheet that will guide students' review of Internet resources on metals.

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.

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

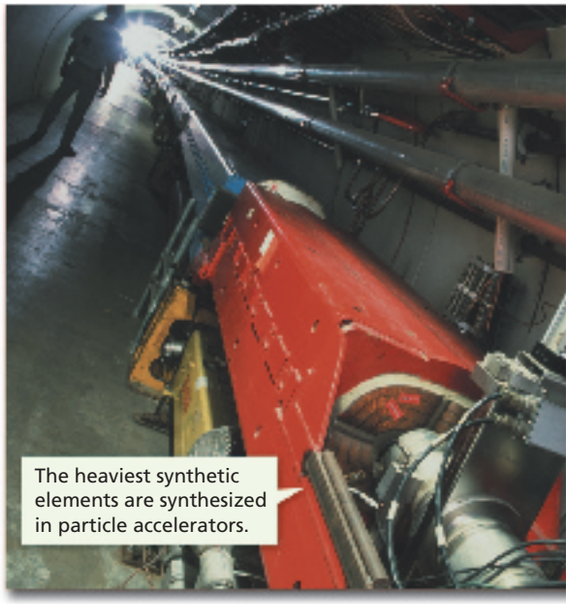


FIGURE 19
Synthetic Elements
Synthetic elements are not found naturally on Earth.

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.

Lab zone At-Home Activity

Everyday Metals L1 Students' answers should list metals in many household items and should describe how the properties of each metal make it useful.

Lab zone Chapter Project

Keep Students on Track Encourage students to think about properties to observe in their metals, such as shininess, hardness, and color. Also, encourage them to plan how to test other properties of metals such as corrosion, magnetism, conductivity, density, and reactivity with acids and oxygen. Review their designs and make sure they have addressed safety issues.

Monitor Progress L2

Answers

Figure 18 Sample answer: What high-energy particles does curium produce, and how are the particles used?

Reading Checkpoint Below the lanthanides; in Period 7

Reading Checkpoint Elements with atomic numbers higher than 92, because they are not found naturally on Earth

Assess

Reviewing Key Concepts

1. a. Physical properties; conductivity—the ability of an object to transfer heat or electricity to another object; ductility—the ability of a material to be pulled out into a wire **b.** Sample answer: Copper's ductility allows copper to be drawn into wires that carry electricity. **c.** Metals are good conductors of heat. Plastic or wood handles, which do not conduct heat, protect hands from the heat.
2. a. Group 1, or alkali metals **b.** Metals that are farthest right because reactivity of metals decreases from left to right **c.** Element 120 would likely have reactivity similar to that of the alkaline earth metals.
3. a. New elements are synthesized when atomic nuclei are forced to crash into the nuclei of other elements with enough energy to combine into a single nucleus. **b.** Plutonium is made by bombarding nuclei of uranium-238 with neutrons in a nuclear reactor.

Reteach L1

Give students a black-and-white copy of the periodic table. Have them color-code the locations of the six categories of metals described in the section. Then have them make a key that identifies the locations and properties of each group.

Performance Assessment L2

Oral Presentation Have students choose one metal from Groups 1 to 13, then describe themselves as if they were that metal, including their position in the periodic table and their properties.

All in One Teaching Resources

- Section Summary: *Metals*
- Review and Reinforce: *Metals*
- Enrich: *Metals*

Lab zone Consumer Lab

Copper or Carbon? That Is the Question

L2

Prepare for Inquiry

Key Concept
The properties of elements determine their uses.

Skills Objectives
After this lab, students will be able to
- observe properties of copper and carbon.
- classify substances as metals or nonmetals.
- control variables in an experiment.
- draw conclusions about the best uses of substances based on their properties.

Prep Time 15 minutes
Class Time 30 minutes

Advance Planning
The diameters of the copper wire and graphite should be about the same. Consider assembling the conductivity testers in advance.

Alternative Materials
Any heat resistant container may be used in place of the beaker.

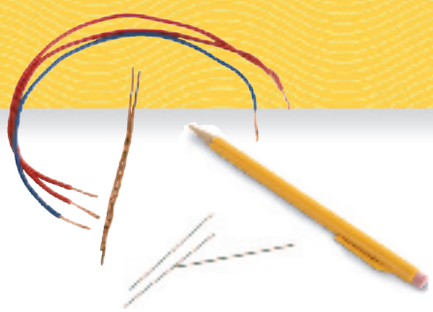
Safety
Caution students to keep water away from the electrical apparatus, electrical outlets, and the hot plate. Make sure students turn off the hot plate before conducting the experiment. Review the safety guidelines in Appendix A.

All in One Teaching Resources
- Lab Worksheet: *Copper or Carbon? That Is the Question*

Guide Inquiry

Invitation
Invite students to give examples of items made of metal. *(Sample answers: tools, cookware, airplanes, cars)* Ask: **What characteristics do these items have in common?** *(Sample answer: They are hard, shiny, and strong.)* Display a piece of sulfur, graphite, or other nonmetal. Invite students to describe its characteristics and compare them to those of metals.

Lab zone Consumer Lab



Copper or Carbon? That Is the Question

Problem
Materials scientists work to find the best materials for different products. In this lab, you will look for an answer to the following problem: How do the properties of copper and graphite determine their uses? You will compare the properties of a copper wire and a pencil lead. Pencil lead is made mostly of graphite, a form of the nonmetal element carbon.

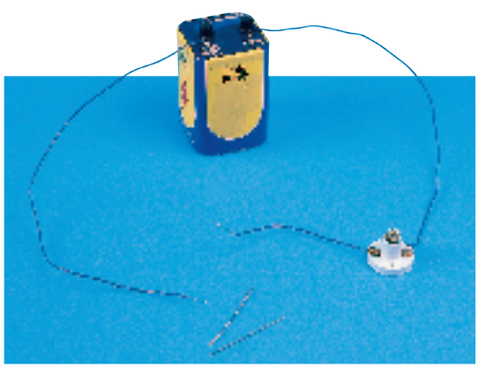
Skills Focus
observing, classifying, controlling variables, drawing conclusions

Materials
- 1.5-V dry cell battery
- 250-mL beaker • stopwatch
- flashlight bulb and socket
- 3 lengths of insulated wire
- thin copper wire with no insulation, about 5–6 cm long
- 2 graphite samples (lead from a mechanical pencil), each about 5–6 cm long
- hot plate • water

Procedure
1. Fill a 250-mL beaker about three-fourths full with water. Heat it slowly on a hot plate. Let the water continue to heat as you complete Part 1 and Part 2 of the investigation.

PART 1 Physical Properties
2. Compare the shininess and color of your copper and graphite samples. Record your observations.
3. Bend the copper wire as far as possible. Next, bend one of the graphite samples as far as possible. Record the results of each test.

PART 2 Electrical Conductivity
4. Place a bulb into a lamp socket. Use a piece of insulated wire to connect one pole of a dry cell battery to the socket, as shown in the photo below.
5. Attach the end of a second piece of insulated wire to the other pole of the dry cell battery. Leave the other end of this wire free.
6. Attach the end of a third piece of insulated wire to the other pole of the lamp socket. Leave the other end of this wire free.



7. Touch the free ends of the insulated wire to the ends of the copper wire. Record your observations of the bulb.
8. Repeat Step 7 using a graphite sample instead of the copper wire.

Introduce the Procedure
Before students begin the procedure, refer them to the photograph of the conductivity tester. Demonstrate how to assemble and use the tester. Also demonstrate how to test for heat conductivity. Emphasize the importance of using equal lengths of copper and graphite. Then, ask: **What element is graphite a form of?** *(Carbon)*

Troubleshooting the Experiment
- Have plenty of graphite pencil leads available, as they break easily.
- In the conductivity test, make sure students do not touch the wires together or place them too close to each other on the copper or graphite as the light might illuminate inadvertently.

Expected Outcome
Copper is shinier, more malleable, and conducts heat and electricity better than graphite.

PART 3 Heat Conductivity

9. Turn off the hot plate.
10. Hold one end of a graphite sample between the fingertips of one hand. Hold one end of the copper wire between the fingertips of the other hand. **CAUTION:** *Be careful not to touch the beaker.*
11. Dip both the graphite and copper wire into the hot water at the same time. Allow only about 1 cm of each piece to reach under the water's surface. From your fingertips to the water, the lengths of both the graphite sample and the copper wire should be approximately equal.
12. Time how long it takes to feel the heat in the fingertips of each hand. Record your observations.

Analyze and Conclude

1. **Observing** Compare the physical properties of copper and graphite that you observed.
2. **Classifying** Based on the observations you made in this lab, explain why copper is classified as a metal.
3. **Controlling Variables** In Step 11, why was it important to use equal lengths of copper wire and graphite?
4. **Drawing Conclusions** Which of the two materials, graphite or copper, would work better to cover the handle of a frying pan? Explain your choice.
5. **Communicating** Write a paragraph explaining why copper is better than graphite for electrical wiring. Include supporting evidence from your observations in this lab.

More to Explore

Research other uses of copper in the home and in industry. For each use, list the physical properties that make the material a good choice.

Analyze and Conclude

1. Copper is shiny, hard, and flexible. Graphite is dull, relatively soft (shown in its ability to leave a mark on paper), and easily broken (brittle).

2. Copper is classified as a metal because it is hard, shiny, ductile, and a good conductor of heat and electricity.

3. The manipulated variable in the experiment is the identity of the substance: carbon versus copper. All other factors, including the length of the sample and the temperature of the water, must be kept constant.

4. Graphite would work better to cover the handle of a frying pan because it has a lower heat conductivity than does copper.

5. Students' paragraphs should emphasize properties such as more flexibility, ductility, and greater electrical conductivity that would make copper the better choice for electrical wiring.

Extend Inquiry

More to Explore Students may list a variety of uses for copper. For each use listed, make sure students assign a relevant property that is consistent with the material.