

## Lesson 2

### Reading Guide

#### Key Concepts

##### ESSENTIAL QUESTIONS

- What elements are metals?
- What are the properties of metals?

#### Vocabulary

**metal** p. 355

**luster** p. 355

**ductility** p. 356

**malleability** p. 356

**alkali metal** p. 357

**alkaline earth metal** p. 357

**transition element** p. 358



Multilingual eGlossary

# Metals

### Inquiry

## Where does it strike?

Lightning strikes the top of the Empire State Building approximately 100 times a year. Why does lightning hit the top of this building instead of the city streets or buildings below? Metal lightning rods allow electricity to flow through them more easily than other materials do. Lightning moves through these materials and the building is not harmed.






### What properties make metals useful?

The properties of metals determine their uses. Copper conducts thermal energy, which makes it useful for cookware. Aluminum has low density, so it is used in aircraft bodies. What other properties make metals useful?

- 1 Read and complete a lab safety form.
- 2 With your group, observe the **metal objects** in your **container**. For each object, discuss what properties allow the metal to be used in that way.
- 3 Observe the **photographs of gold and silver jewelry**. What properties make these two metals useful in jewelry?
- 4 Examine **other objects around the room** that you think are made of metal. Do they share the same properties as the objects in your container? Do they have other properties that make them useful?




#### Think About This

1. What properties do all the metals share? What properties are different?
2.  **Key Concept** In your Science Journal, list at least four properties of metals that determine their uses.

### What is a metal?

What do stainless steel knives and forks, copper wire, aluminum foil, and gold jewelry have in common? They are all made from metals.

As you read in Lesson 1, most of the elements on the periodic table are metals. In fact, of all the known elements, more than three-quarters are metals. With the exception of hydrogen, all of the elements in groups 1-12 on the periodic table are metals. In addition, some of the elements in groups 13-15 are metals. To be a metal, an element must have certain properties.

-  **Key Concept Check** How does the position of an element on the periodic table allow you to determine if the element is a metal?

### Physical Properties of Metals

Recall that physical properties are characteristics used to describe or identify something without changing its makeup. All metals share certain physical properties.

A **metal** is an element that is generally shiny. It is easily pulled into wires or hammered into thin sheets. A metal is a good conductor of electricity and thermal energy. Gold exhibits the common properties of metals.


**Luster and Conductivity** People use gold for jewelry because of its beautiful color and metallic luster. **Luster** describes the ability of a metal to reflect light. Gold is also a good conductor of thermal energy and electricity. However, gold is too expensive to use in normal electrical wires or metal cookware. Copper is often used instead.



## Properties of Metals

**Figure 8** Gold has many uses based on its properties.



 **Visual Check** Analyze why the properties shown in each photo are an advantage to using gold.

### WORD ORIGIN

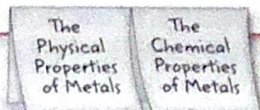
**ductility**  
from Latin *ductilis*, means  
"may be led or drawn"

### REVIEW VOCABULARY

**density**  
the mass per unit volume of a  
substance

### FOLDABLES


Make a two-tab book. Label it as shown. Use it to record information about the properties of metals.



**Ductility and Malleability** Gold is the most ductile metal. **Ductility** (duk TIH luh tee) is the ability to be pulled into thin wires. A piece of gold with the mass of a paper clip can be pulled into a wire that is more than 3 km long.

**Malleability** (ma lee uh BIH luh tee) is the ability of a substance to be hammered or rolled into sheets. Gold is so malleable that it can be hammered into thin sheets. A pile of a million thin sheets would be only as high as a coffee mug.

**Other Physical Properties of Metals** In general the **density**, strength, boiling point, and melting point of a metal are greater than those of other elements. Except for mercury, all metals are solid at room temperature. Many uses of a metal are determined by the metal's physical properties, as shown in **Figure 8**.

 **Key Concept Check** What are some physical properties of metals?

### Chemical Properties of Metals

Recall that a chemical property is the ability or inability of a substance to change into one or more new substances. The chemical properties of metals can differ greatly. However, metals in the same group usually have similar chemical properties. For example, gold and other elements in group 11 do not easily react with other substances.



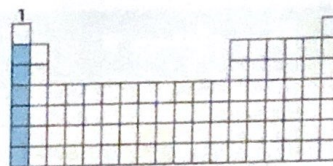
© 2011 Pearson Education, Inc. All rights reserved. This material is intended for use only in the context of the Pearson Education, Inc. publishing program. No part of this material may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, without prior written permission from Pearson Education, Inc.

## Group 1: Alkali Metals

The elements in group 1 are called **alkali** (AL kuh li) **metals**. The alkali metals include lithium, sodium, potassium, rubidium, cesium, and francium.

Because they are in the same group, alkali metals have similar chemical properties. Alkali metals react quickly with other elements, such as oxygen. Therefore, in nature, they occur only in compounds. Pure alkali metals must be stored so that they do not come in contact with oxygen and water vapor in the air. **Figure 9** shows potassium and sodium reacting with water.

Alkali metals also have similar physical properties. Pure alkali metals have a silvery appearance, as shown in **Figure 9**. They are soft enough to cut with a knife. The alkali metals also have the lowest densities of all metals. A block of pure sodium metal could float on water because of its very low density.



### Animation

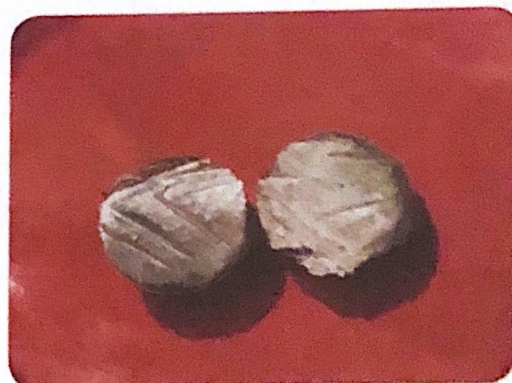
**Figure 9** Alkali metals react violently with water. Freshly cut surfaces are also shiny.



**Potassium**



**Sodium**




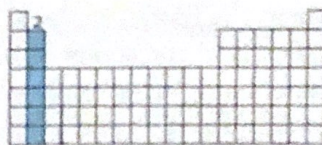
**Lithium**

## Group 2: Alkaline Earth Metals

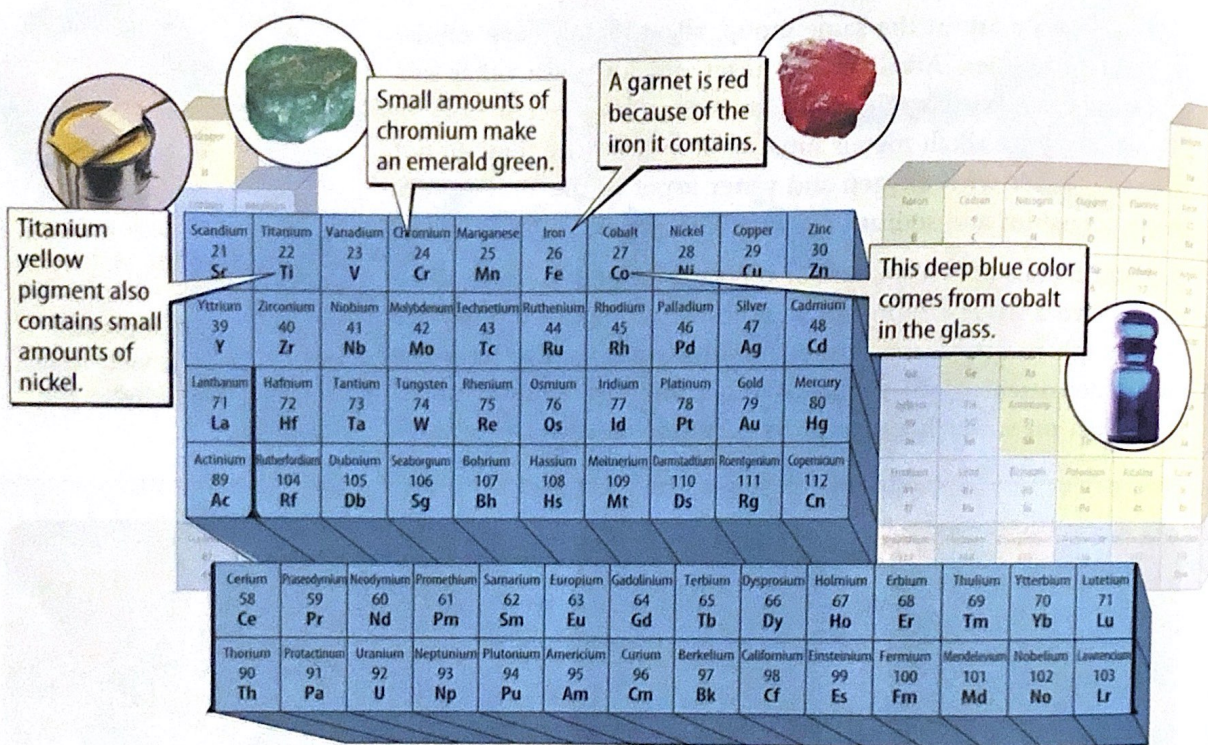
The elements in group 2 on the periodic table are called **alkaline** (AL kuh lun) **earth metals**. These metals are beryllium, magnesium, calcium, strontium, barium, and radium.

Alkaline earth metals also react quickly with other elements. However, they do not react as quickly as the alkali metals do. Like the alkali metals, pure alkaline earth metals do not occur naturally. Instead, they combine with other elements and form compounds. The physical properties of the alkaline earth metals are also similar to those of the alkali metals. Alkaline earth metals are soft and silvery. They also have low density, but they have greater density than alkali metals.

 **Reading Check** Which element reacts faster with oxygen—barium or potassium?



**Figure 10** Transition elements are the blocks at the center of the periodic table. Many colorful materials contain small amounts of transition elements.



## Groups 3–12: Transition Elements

The elements in groups 3–12 are called **transition elements**. The transition elements are in two blocks on the periodic table. The main block is in the center of the periodic table. The other block includes the two rows at the bottom of the periodic table, as shown in **Figure 10**.

### Properties of Transition Elements

All transition elements are metals. They have higher melting points, greater strength, and higher densities than the alkali metals and the alkaline earth metals. Transition elements also react less quickly with oxygen. Some transition elements can exist in nature as free elements. An element is a free element when it occurs in pure form, not in a compound.

### Uses of Transition Elements

Transition elements in the main block of the periodic table have many important uses. Because of their high densities, strength, and resistance to corrosion, transition elements such as iron make good building materials. Copper, silver, nickel, and gold are used to make coins. These metals are also used for jewelry, electrical wires, and many industrial applications.

Main-block transition elements can react with other elements and form many compounds. Many of these compounds are colorful. Artists use transition-element compounds in paints and pigments. The color of many gems, such as garnets and emeralds, comes from the presence of small amounts of transition elements, as illustrated in **Figure 10**.



## Lanthanide and Actinide Series

Two rows of transition elements are at the bottom of the periodic table, as shown in **Figure 10**. These elements were removed from the main part of the table so that periods 6 and 7 were not longer than the other periods. If these elements were included in the main part of the table, the first row, called the lanthanide series, would stretch between lanthanum and hafnium. The second row, called the actinide series, would stretch between actinium and rutherfordium.

Some lanthanide and actinide series elements have valuable properties. For example, lanthanide series elements are used to make strong magnets. Plutonium, one of the actinide series elements, is used as a fuel in some nuclear reactors.

## Patterns in Properties of Metals

Recall that the properties of elements follow repeating patterns across the periods of the periodic table. In general, elements increase in metallic properties such as luster, malleability, and electrical conductivity from right to left across a period, as shown in **Figure 11**. The elements on the far right of a period have no metallic properties at all. Potassium (K), the element on the far left in period 4, has the highest luster, is the most malleable, and conducts electricity better than all the elements in this period.

There are also patterns within groups. Metallic properties tend to increase as you move down a group, also shown in **Figure 11**. You could predict that the malleability of gold is greater than the malleability of either silver or copper because it is below these two elements in group 11.

**✓ Reading Check** Where would you expect to find elements on the periodic table with few or no metallic properties?



## MiniLab

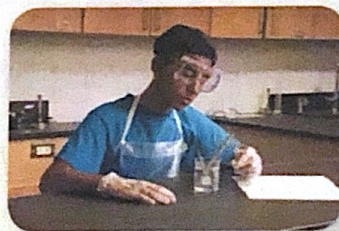
20 minutes

### How well do materials conduct thermal energy?



How well a material conducts thermal energy can often determine its use.

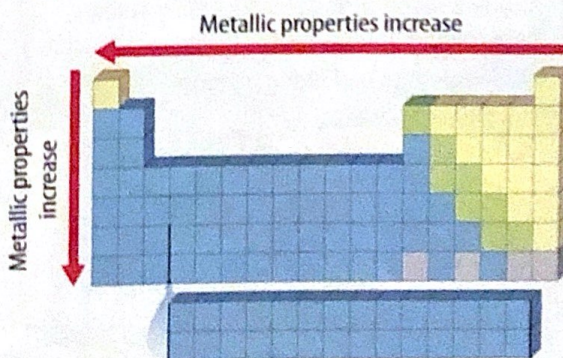
- 1 Read and complete a lab safety form.
- 2 Have your teacher add about 200 mL of very **hot water** to a **250-mL beaker**.
- 3 Place **rods of metal, plastic, glass, and wood** in the water for 30 seconds.
- 4 Set four large **ice cubes** on a sheet of **paper towel**. Use **tongs** to quickly remove each rod from the hot water. Place the heated end of the rod on an ice cube.
- 5 After 30 seconds, remove the rods and examine the ice cubes.



### Analyze and Conclude

1. **Conclude** What can you conclude about how well metals conduct thermal energy?
2. **Key Concept** Cookware is often made of metal. What property of metals makes them useful for this purpose?

**Figure 11** Metallic properties of elements increase as you move to the left and down on the periodic table.



# Lesson 2 Review



## Visual Summary



Properties of metals include conductivity, luster, malleability, and ductility.



Alkali metals and alkaline earth metals react easily with other elements. These metals make up groups 1 and 2 on the periodic table.



Transition elements make up groups 3–12 and the lanthanide and actinide series on the periodic table.

## FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

## What do you think NOW?

You first read the statements below at the beginning of the chapter.

3. Fewer than half of the elements are metals.
4. Metals are usually good conductors of electricity.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

## Use Vocabulary

- 1 Use the term *luster* in a sentence.
- 2 Identify the property that makes copper metal ideal for wiring.
- 3 Elements that have the lowest densities of all the metals are called \_\_\_\_\_.

## Understand Key Concepts

- 4 List the physical properties that most metals have in common.
- 5 Which is a chemical property of transition elements?
  - A. brightly colored
  - B. great ductility
  - C. denser than alkali metals
  - D. reacts little with oxygen
- 6 Organize the following metals from least metallic to most metallic: barium, zinc, iron, and strontium.

## Interpret Graphics

- 7 Examine this section of the periodic table. What metal will have properties most similar to those of chromium (Cr)? Why?

Vanadium 23 V	Chromium 24 Cr	Manganese 25 Mn
Niobium 41 Nb	Molybdenum 42 Mo	Technetium 43 Tc

## Critical Thinking

- 8 Investigate your classroom and locate five examples of materials made from metal.
- 9 Evaluate the physical properties of potassium, magnesium, and copper. Select the best choice to use for a building project. Explain why this metal is the best building material to use.

# Fireworks

### Metals add a variety of colors to fireworks.

About 1,000 years ago, the Chinese discovered the chemical formula for gunpowder. Using this formula, they invented the first fireworks. One of the primary ingredients in gunpowder is saltpeter, or potassium nitrate. Find potassium on the periodic table. Notice that potassium is a metal. How does the chemical behavior of a metal contribute to a colorful fireworks show?

Blue: copper compounds

Yellow: sodium compounds

Gold: iron burned with carbon

White-hot: barium-oxygen compounds or aluminum or magnesium burn

Orange: calcium compounds

Green: barium compounds

Purple: mix of strontium and copper compounds

Metal compounds contribute to the variety of colors you see at a fireworks show. Recall that metals have special chemical and physical properties. Compounds that contain metals also have special properties. For example, each metal turns a characteristic color when burned. Lithium, an alkali metal, forms compounds that burn red. Copper compounds burn blue. Aluminum and magnesium burn white.

Red: strontium and lithium compounds

### It's Your Turn

**FORM AN OPINION** Fireworks contain metal compounds. Are they bad for the environment or your health? Research the effects of metals on human health and on the environment. Decide if fireworks are safe to use for holiday celebrations.

