

CHAPTER 5 Elements, Compounds, and Mixtures

SECTION

1

Elements

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is an element?
- How do elements differ from other materials?
- How are elements classified?



California Science
Standards

8.7.c

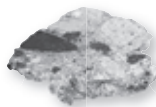
What Are Elements?

Many materials can be broken down into different components. For example, some rocks contain copper. When they are heated in a large furnace, the copper separates from the rest of the rock. Another example is the breakdown of water when electricity is passed through it. The electric current causes hydrogen and oxygen gases to form.

Some materials cannot be separated or broken down into other materials. An **element** is a pure substance that cannot be separated into simpler substances by chemical or physical methods. This is how elements are different from all other materials.

A **pure substance** is a material in which all of the basic particles are identical. All of the particles of a pure substance are alike, no matter where the substance is found. Pure substances that are not elements can be broken down into simpler substances. ✓

The basic particles of an element are called *atoms*. Copper is an example of an element. All of the atoms in a piece of pure copper are alike. As shown in the figure below, iron is also an element.



The atoms of iron in the meteorite from space are identical to the atoms of iron in a steel spoon. There are also atoms of iron in the cereal, in the boy's braces, and even in his blood.

**STUDY TIP**

Organize In your notebook, make a concept map, using the terms *element*, *substance*, *metal*, *nonmetal*, and *metalloid*.

READING CHECK

1. Compare How do elements differ from other pure substances?

TAKE A LOOK

2. Identify Look at the illustration, and identify one source of iron that comes to Earth from somewhere else.

SECTION 1 Elements *continued*

How Can Elements Be Classified?

Elements can be classified based on their properties. There are two types of properties, chemical and physical. Characteristic physical properties include hardness, melting point, and density. Chemical properties include reactivity and flammability. ✓

Two elements may have a particular property in common, but you can use other properties to tell them apart. For example, the elements helium and krypton are both colorless, odorless, unreactive gases. However, these elements have different densities (mass per unit volume). Helium is less dense than air, so a helium balloon floats upward. A krypton-filled balloon, on the other hand, would sink to the floor. Krypton is denser than air.

READING CHECK

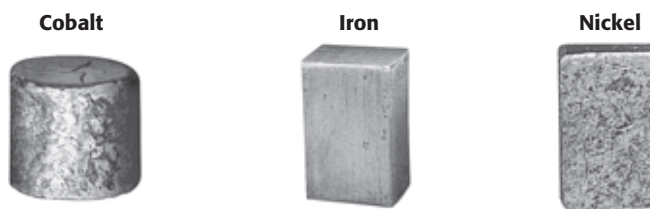
3. List What are three physical properties that are characteristics of an element?

Critical Thinking

4. Make Inferences

Compare the properties of iron with those of cobalt and nickel. How do you think cobalt and nickel are used in manufactured products?

Unique Properties of Elements



- | | | |
|---|---|---|
| <ul style="list-style-type: none"> • Melting point: 1,495°C • Density: 8.9 g/cm³ • Conducts electricity and heat. • Reactivity: Does not react with oxygen in the air. | <ul style="list-style-type: none"> • Melting point: 1,535°C • Density: 7.9 g/cm³ • Conducts electricity and heat. • Reactivity: Reacts by combining with oxygen in the air to form rust. | <ul style="list-style-type: none"> • Melting point: 1,455°C • Density: 8.9 g/cm³ • Conducts electricity and heat. • Reactivity: does not react with oxygen in the air. |
|---|---|---|

The figure above shows some of the properties of three different elements. The physical properties shown are melting point, electrical and thermal conductivities, and density. Each element has other physical properties, as well, including color, hardness, and texture. The figure also includes a chemical property—the reactivity of the element with oxygen in the air.

If you had a piece of metal, could you determine which of the elements it was, based on these properties? Iron can be distinguished from both other elements by physical and chemical properties. The density of iron is much less than that of either cobalt or nickel, and it reacts with oxygen in the air.

You can't use those properties to tell nickel and cobalt apart. However, their melting points differ by 40°C. So, you can use melting points to tell them apart. ✓

READING CHECK

5. Explain Why can't you use the density or reactivity with air to determine whether a sample is cobalt or nickel?

SECTION 1 Elements *continued***How Can Elements Be Sorted?**

Think about all the different types of dogs that you have seen. Dogs can be classified based on different properties. These include size, ear shape, and length of coat. You can often determine a dog's breed just with a quick glance. The figure below shows three kinds of terriers. They are not exactly alike, but they share some properties.



Even though these dogs are different breeds, they have enough in common to be classified as terriers.

The elements can be sorted based on properties, just as the dogs in the illustration can. There are three major categories of elements: metals, nonmetals, and metalloids. The elements iron, cobalt, and nickel are all metals. They are not exactly alike, but they have similar properties. ✓

Metals tend to be shiny solids (except mercury, which is a shiny liquid). Metals conduct heat and electric current well. **Nonmetals** do not conduct heat or electric current very well. Many nonmetals are gases. The solid nonmetals have a dull appearance. **Metalloids** have some of the properties of metals and some of the properties of nonmetals. Metalloids are important in electronics because their electrical conductivity can vary with conditions.

Three Major Categories of Elements			
Property	Metals	Nonmetals	Metalloids
Appearance	shiny	dull	some shiny
Conductivity of heat and electricity	good	poor	some good
Malleability—ability to be hammered into sheets	malleable	not malleable	some somewhat malleable
Ductility—ability to be made into wires	ductile	not ductile	some somewhat ductile
Brittleness	not brittle	brittle	some brittle

TAKE A LOOK

6. Describe What are some of the physical properties that describe terriers?

READING CHECK

7. Identify What are the three main categories of elements?

 **Say It**

Explore Applications The properties of metals make them very useful in everyday things. In groups of three or four, make a list of things that you use for cooking that are made of metal. Make another list of things used for cooking that are never made of metal. Discuss why the properties of metals determine which things are in which group.

Section 1 Review

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SECTION VOCABULARY

element a substance that cannot be separated or broken down into simpler substances by chemical means

metal an element that is shiny and conducts heat and electricity well

metalloid an element that has properties of both metals and nonmetals

nonmetal an element that conducts heat and electricity poorly

pure substance a sample of matter, either a single element or a single compound, that has definite chemical and physical properties

1. Compare How does the ability to conduct heat differ between metals and nonmetals?

2. Classify Fill in the blanks to complete the table.

Element	Property	Classification
Copper	shiny solid	
Oxygen	gas	
Silicon	Electrical conductivity varies, depending on conditions.	

3. Evaluate Assumptions Your friend tells you that all of the electric wires in your home are metals. From what you know about elements, tell whether or not this statement is true. Explain your answer.

4. Apply Concepts Several elements are used between the panes of glass in double windows designed to block heat flow. From what category are these elements chosen. How do you know?

5. Make Calculations Two elements, hydrogen and helium, make up most of the atoms in the universe: 92.7% of atoms are hydrogen, and 6.9% of atoms are helium. What percentage of atoms in the universe is neither hydrogen nor helium? Show your work.