

CHAPTER 3 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?

National Science Education Standards

PS 1a, 1c

What Are Elements?

Many materials can be broken down into simpler materials. 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 breaking down water by passing electricity through it. The electric current causes hydrogen gas and oxygen gas 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 the basic particles are the same. For example, table salt contains particles of sodium chloride. Table salt from anywhere is the same. All pure substances, except for 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 iron atoms in the meteorite from space are the same as the iron atoms in a steel spoon. There are also iron atoms in the cereal, in the boy's braces, and even in his blood.

**STUDY TIP**

Graphic Organizer In your notebook, make a Concept Map by using the terms element, substance, metal, nonmetal, and metalloid.

READING CHECK

1. Compare How does an element 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*

STANDARDS CHECK

PS 1a A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.

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

Critical Thinking

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

READING CHECK

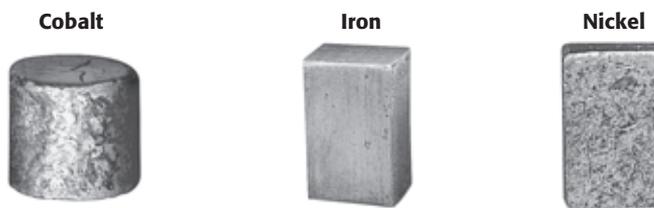
5. Explain Why can't you use density or reactivity to determine whether a sample is cobalt or nickel?

How Can Elements Be Classified?

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

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

The Unique Properties of Elements



- | | | |
|--|---|--|
| <p>Cobalt</p> <ul style="list-style-type: none"> • Melting point: 1,495°C • Density: 8.9 g/cm³ • Conducts electricity and heat • Reactivity: unreactive with oxygen in the air | <p>Iron</p> <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. | <p>Nickel</p> <ul style="list-style-type: none"> • Melting point: 1,455°C • Density: 8.9 g/cm³ • Conducts electricity and heat • Reactivity: unreactive 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, 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, you could use these properties to determine which element it is. Iron has different physical and chemical properties than the other two elements. The density of iron is much less than cobalt or nickel, and it reacts with oxygen in the air.

We can also use properties to tell nickel and cobalt apart. They have the same density and reactivity, but the melting points of these two elements differ by 40°C. This property can be used to tell them apart. ✓

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 their size, the shape of the ears, or the length of their 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 certain features.



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

The elements can be classified based on properties, just like the dogs in the image. 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 electric current and heat 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 are shiny
Conductivity of heat and electricity	good	poor	some do
Malleable—can be hammered into sheets	yes	no	some are somewhat malleable
Ductile—can be made into wires	yes	no	some are somewhat ductile
Brittle	no	yes	some are

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 metal determined which things are in which group.

Section 1 Review

NSES PS 1a, 1c

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 each blank 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, explain whether or not this statement is true.

4. Apply Concepts Several elements are placed between panes of glass in double windows to block heat flow. Should these elements be metals or nonmetals? Why?

5. Calculate 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 are neither hydrogen nor helium? Show your work.