Topic 2.3

What are pure substances and how are they classified?

Key Concepts

- Pure substances are elements and compounds.
- Elements include metals and non-metals.

Key Skills

Research

Key Terms

pure substance
element
compound
metals
non-metal

What do the two photos have in common? Photo A shows two people fishing with a dip net. You have used a similar tool if you have ever gone fishing or scooped a pet fish out of an aquarium. A dip net is a traditional Aborginal tool designed to separate big fish from smaller fish or water.

The device in Photo B is a piece of equipment that is often used in crime labs. The person uses the device to analyze and identify the types of matter in or on a sample from a crime scene.

The devices in Photos A and B use properties to separate mixtures of matter into their parts. The dip net uses the properties of size and state—in this case, whether something is a solid or a liquid. The crime-lab device uses different properties. But not all types of matter can be separated into parts easily, and some types of matter can't be separated at all. Why might that be?

Starting Point Activity

When you read the word "pure" on a product label, what do you think it means? Does "pure" mean the same thing to you as it does to someone else who looks at the same product label? Does it mean the same thing to a scientist? Classify some common materials as either mixtures or pure substances.

What To Do

1. Work in groups. Decide together how to define the words "mixture" and "pure substance." Record your definitions.
2. Make a table of observations that starts like this.

Product	Mixture or pure substance?	Reasons for your choice

3. Brainstorm a list of common products that you might find at home in the kitchen or bathroom or both.
4. Choose 10 of your brainstormed products to classify as a mixture or a pure substance. Fill out your table for each of these. Use the definitions that you developed in step 1 to help you decide how to classify each product.

What Did You Find Out?

1. Compare your products and classifications with other groups. How many mixtures were there? How many pure substances were there?
2. Which products were easy to classify? Which ones were hard? Explain.
3. At any time, did you modify your definitions or think about modifying them? Explain.

Pure substances are elements and compounds.

Matter is usually classified by its physical and chemical properties. When scientists first worked on classifying matter, they grouped matter based on how they could break it apart. Matter that could be separated into parts using differences in physical properties was classified as a *mixture*. Mixtures are made up of two or more types of matter, and these types can be physically separated.

pure substance: matter that contains only one type of particle

Matter that is not a mixture is a pure substance. A **pure substance** is made up of only one type of matter, so it cannot be separated into parts physically. Table sugar (sucrose) is a pure substance. So is oxygen. Other examples of pure substances include pure water, copper, and aluminum.

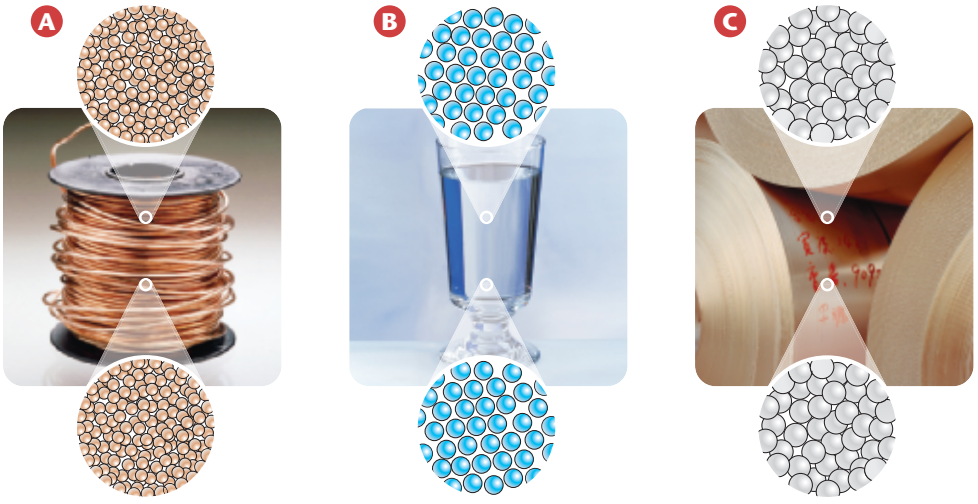
Each part of a pure substance has the same properties, because each pure substance is made up of its own type of particle. The kind of particle that makes up one pure substance is different from the kinds of particles that make up other pure substances. Use Figure 2.4 to help you understand what this means. (If you need help to recall the concept that all matter is made up of particles, refer to the Get Ready for this unit, on page 92.)

compound: a pure substance made up of two or more elements that are chemically combined; can be broken down into elements again by chemical means

There are two main types of pure substances. Pure substances that can be broken down into smaller parts using chemical reactions are called **compounds**. Pure substances that can't be broken down using chemical reactions are called **elements**.

element: a pure substance made up of one type of particle that cannot be broken down into simpler parts by chemical means

Why can compounds be broken down into smaller parts and elements can't? Compounds can be broken down into smaller parts, because they contain more than one type of element. For instance, look at Figure 2.5 on the next page.



▶ **Figure 2.4** Copper, pure (distilled) water, and aluminum are examples of pure substances. In (A), notice that any part of copper is made up only of copper particles. See how this same idea applies to water and aluminum in (B) and (C).

In **Figure 2.5**, you can see a piece of metal, a sealed glass flask, and a white powdery solid. If you look closely at the flask, you can see a pale yellow colour inside. That is a gas. The gas is the element chlorine. The silvery-grey solid is a metal. The metal is the element sodium. These two elements, chlorine and sodium, can combine together to form the compound table salt. Energy can be used to un-combine the compound into the two individual elements again. The elements, however, cannot be un-combined further with a chemical reaction.

Chlorine combines with other elements to make other compounds, too. For example, chlorine combines with calcium to form the compound calcium chloride, which is a type of salt that is used on roads in winter. Other common compounds include table sugar and carbon dioxide.

sodium metal **chlorine gas** **table salt**

▲ **Figure 2.5** The compound table salt is made up of the elements chlorine and sodium, which have combined in a chemical reaction. The scientific term for table salt is sodium chloride.

LEARNING CHECK

1. Explain what a pure substance is. List two examples.
2. Create a flowchart that organizes the following terms: mixture, pure substance, matter, compound, and element. Start your flowchart with matter.
3. Use a double bubble graphic organizer to show similarities and differences between an element and a compound.
4. Look carefully at **Figure 2.4**. Notice that particles from two different parts of each pure substance are shown. Use that information to help you explain why a sample of a pure substance such as copper from Ontario has the same properties as a sample of copper from Peru.

Elements include metals and non-metals.

Research

Activity 2.6

CLASSIFY ELEMENTS

Just as pure substances can be classified as compounds or elements, elements can also be further classified. In this activity, you will investigate the properties of elements, and then classify them based on their properties.

hydrogen	fluorine	argon
helium	neon	potassium
lithium	sodium	calcium
beryllium	magnesium	iron
krypton	aluminum	gold
carbon	mercury	copper
nitrogen	sulfur	nickel
oxygen	chlorine	uranium

Name of element: phosphorus

State at room temperature: solid
Conductivity: no
Solubility in water: no
Reactivity: highly reactive
Combustibility: yes
Reaction with water: no
Some common uses: making fertilizers, making some types of detergents

What To Do

1. Choose one of the elements from the list so that each person has a different element. Your teacher will add other elements as needed. Do research to find key properties and uses for this element. Record the information on an index card such as the sample shown on this page. The sample shows the information you are expected to find.
2. As a class, use the information to classify the elements into groups based on their properties.

What Did You Find Out?

1. What properties did you find the most useful for classifying the elements? Why?

Distinguishing Metals and Non-metals

One way that elements can be classified is to group them into two categories: metals and non-metals. **Metals** are elements that share physical properties such as these. (Refer also to Table 2.2.)

- lustre
- malleability (ability to be bent or hammered without breaking)
- ductility (ability to be stretched into a wire without snapping)
- good conductors

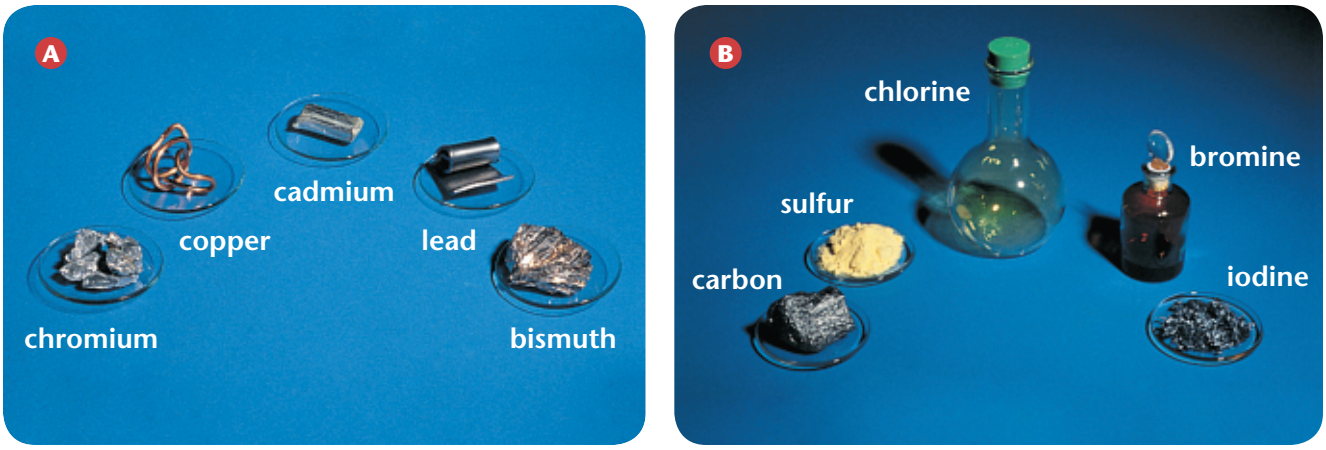
Non-metals are grouped together because they do not share the properties of metals. Table 2.4 compares the properties that help in classifying metals and non-metals. Figure 2.6 shows some examples of metals and non-metals.

metals: elements that are commonly solid at room temperature, shiny, malleable, ductile, and good conductors

non-metals: elements that can be solid, liquid, or gas at room temperature, dull, brittle, not ductile, and poor conductors

Table 2.4 Properties That Help To Distinguish Metals from Non-metals

Substance	State at room temperature	Lustre	Conductivity	Malleability	Ductility
Metals	solid (except mercury, which is liquid)	shiny (lustrous)	good conductors	malleable	ductile
Non-metals	solid, liquid, or gas	dull (not lustrous)	poor conductors	not malleable (brittle)	not ductile



▲ **Figure 2.6** Samples of metals (A) and non-metals (B)

LEARNING CHECK

1. Refer to Figure 2.6. What properties do the metals have in common, and which are different? What properties do the non-metals have in common, and which are different?
2. Make a t-chart to summarize the properties of metals and non-metals.

INVESTIGATION LINK
Investigation 2B, on page 118

Skill Check

- ✓ Initiating and Planning
- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communicating

What You Need

- labelled samples of metals and non-metals
- other equipment and materials as required

Comparing the Physical Properties of Metals with Non-metals

In this investigation, you will plan and perform an experiment to compare and contrast physical properties of metals with non-metals.

What To Do

1. Work together in small groups.
2. Design a procedure to determine the physical properties of the metal and non-metal samples provided by your teacher. Make sure you have your teacher approve your procedure before you begin your experiment. Be sure to consider safety precautions and proper clean-up and disposal in your procedure.

   Consider the following points as you plan your procedure.
   - Refer to **Table 2.2** on page 106 and **Table 2.3** on page 108 to help you as you plan.
   - Your procedure should provide you with at least five physical properties for each of the samples.
   - Make a list of the equipment and materials you will need as you plan.
3. Create a table to record your observations.
4. Follow your procedure and record your results.
5. Clean up and put away all the equipment. Wash your hands.

What Did You Find Out?

1. Copy and complete the table below. Leave enough room for all of the properties that you tested.

Observation Table for Investigation 2B: Summary of Physical Properties

	Metals	Non-metals
Properties shared by all samples		
Properties that are not shared by all samples		

2. What do all metals have in common? All non-metals?
3. Which properties (if any) can't be used to distinguish between a metal and a non-metal?

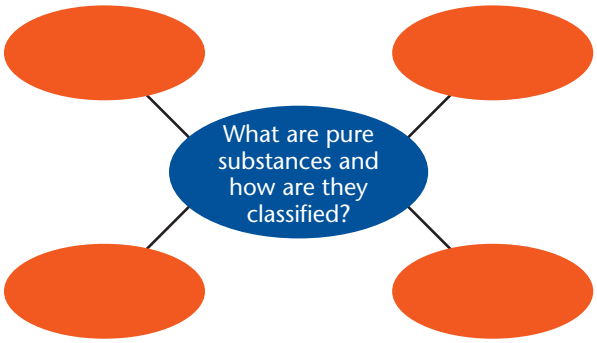
Topic 2.3 Review

Key Concept Summary

- Pure substances are elements and compounds.
- Elements include metals and non-metals.

Review the Key Concepts

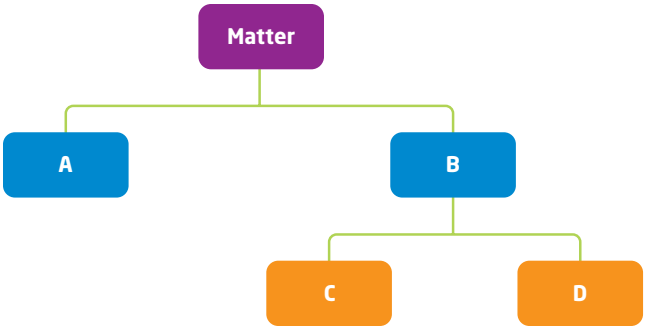
1. K/U Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. T/I Draw a labelled diagram that clearly shows the difference between the pure substance iron and a mixture of iron and sand in terms of the particles that make them up. For help, refer to **Figure 2.4**.

3. K/U What properties of the element aluminum make it desirable for use in constructing aircraft? What properties make it undesirable for this purpose?

4. K/U The flowchart below is part of a classification scheme for matter that focusses on the key concepts that you explored in this topic. Identify the category of matter that is represented by each of the letters.



5. T/I Think about the substances listed in the box below and classify each one as either an element or a compound. Explain how you made your choices.

calcium carbonate	chlorine
copper	neon
table salt	hydrogen peroxide

6. K/U List the physical properties that most metals have in common. Think of an example of a metal and describe how its properties relate to its use.

7. K/U List the physical properties that most non-metals have in common. Think of an example of a non-metal and describe how its properties relate to its use.

8. A What property does steel (a metal) have that makes it a good choice for making car doors?

9. A Steel is a metal that is made from carbon, iron, and small amounts of other elements. When solid steel is heated strongly enough for it to change to a liquid, the elements of which it is made can be separated from one another easily. Based on this information, is steel a pure substance or a mixture? Explain.

10. K/U An element that is a non-metal can be a solid, a liquid, or a gas at room temperature. How, then, can an element that is a non-metal be distinguished from an element that is a non-metal?